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Makes Valves in New Foundry

Desire To Control the Manufacturing Processes Incident to the Production of Its Varied Line of Valves Was the Principal Contributing Factor Toward the Erection of This Steel Foundry

BY H. R SIMONDS

STEEL valve castings designed for service in high pressure lines, oil, air, steam or hydraulic, must conform to rigid specifications and usually are covered by strong guarantees. To stand back of these guarantees and assume the risk implied it is essential that the manufacturer be in close touch with the selection of proper material and be familiar with every step in the process of manufacture. Largely due to a desire to be in closer touch with the methods employed in manufacturing its castings, the Chapman Valve Co., Indian Orchard, Mass., decided to erect and equip a foundry solely for the production of steel castings. This foundry was com-

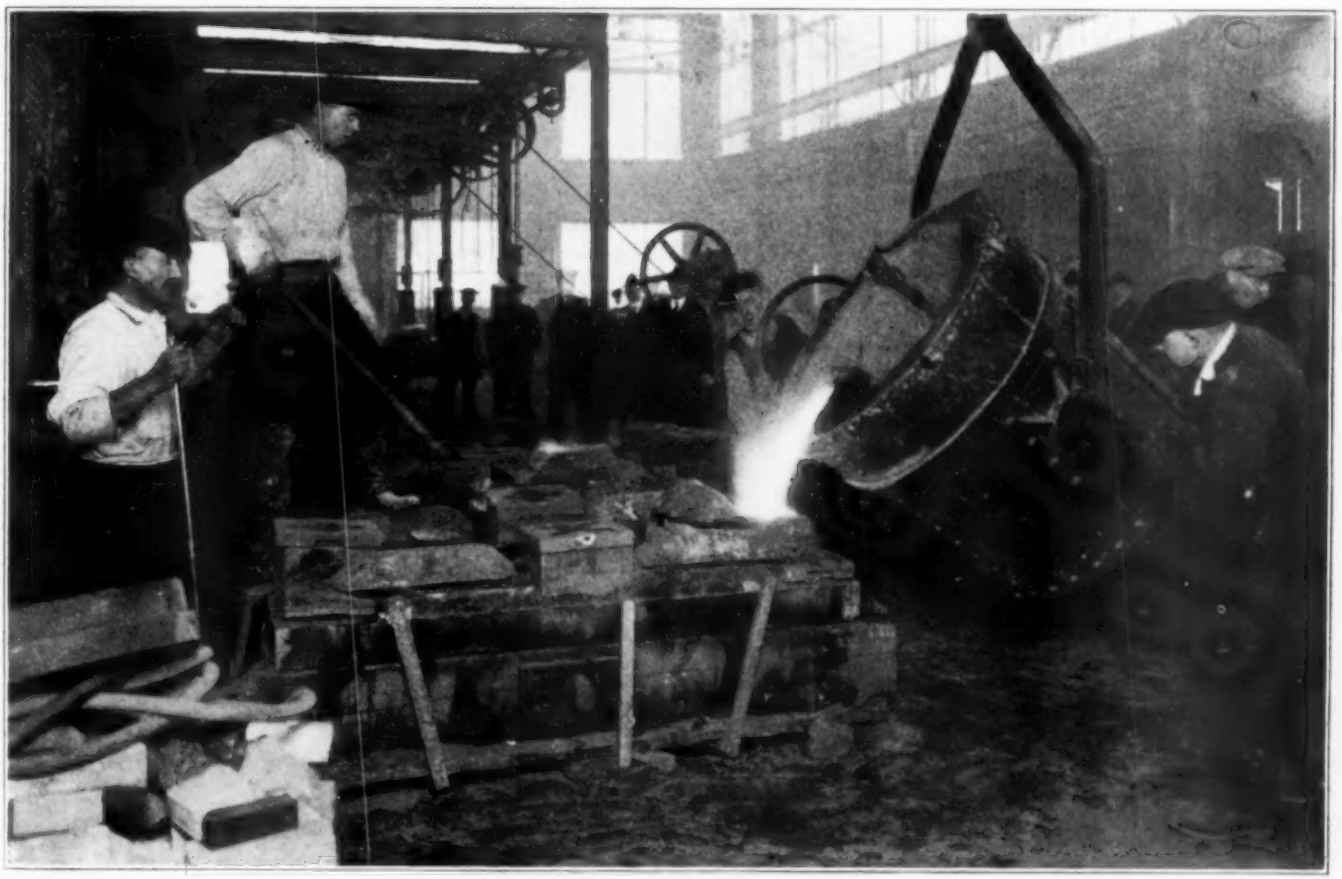


FIG. 1—THE MOLDS ARE SET UP AND POURED ON A SECTION BETWEEN THE MOLDING FLOOR AND THE CLEANING ROOM AND IN THE VICINITY OF THE ELECTRIC MELTING FURNACE

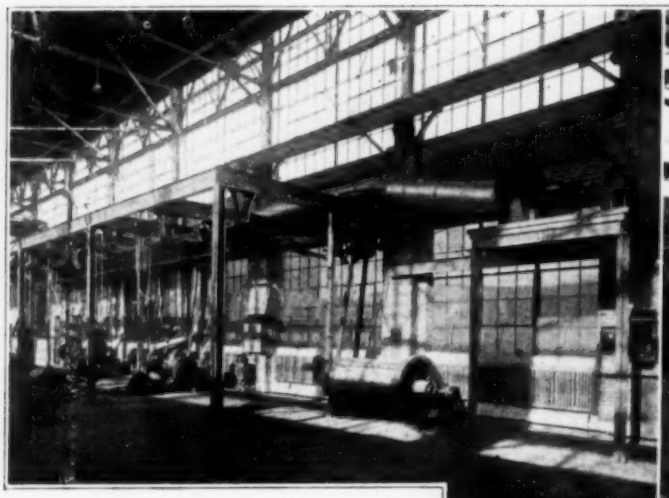


FIG. 2—A STEEL FRAME AT ONE SIDE OF THE CLEANING ROOM SUPPORTS THE SHAFTING AND CHAIN HOISTS

FIG. 3—GENERAL VIEW OF MOLDING FLOOR SHOWING CRANE ARRANGEMENT

pleted in February of this year and has been in continuous service since that time. During this time also, theory and practice have been co-ordinated and manufacturing methods have been developed to a high state of efficiency. Officials state that the reasons for building the new foundry were: first, to enable them to better control the quality and delivery of steel castings to the machine shop: second, to enable them to take advantage of their peculiar location in reference to supply of suitable grade of scrap which is obtained with minimum cost of transportation; and third, to increase efficiency by taking advantage of the present company organization in the process of operating a steel foundry.

Supervised Closely

Edward C. Davis, assistant manager and purchasing agent and P. V. Snow, foundry superintendent, have given close attention to the construction and equipment of the plant in the attempt to secure the best possible steel foundry for the production of valves and allied castings. The progress of material through the foundry is in orderly sequence from the raw material bins at one side to the machine shop and shipping room at the other. The building, of brick and steel construction, is plentifully supplied with windows in the ends, along both sides of the monitor roof and along both side walls of the main bay where they rise above the lower parts of the building on each side. The sand bins, core department and general storage are located on one side of the main bay and the offices, wash and locker rooms and the air compressor room are on the other side.

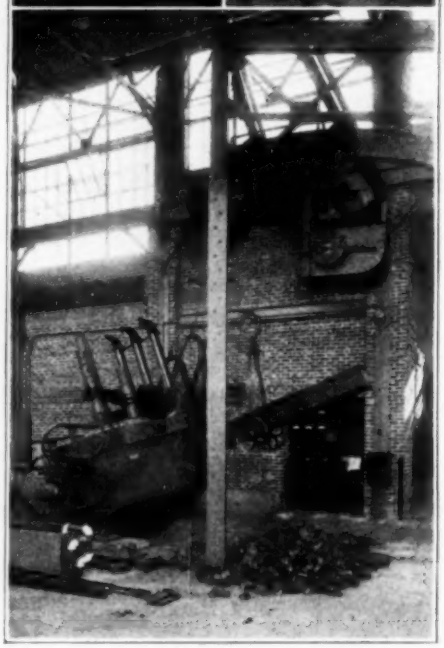


FIG. 4—ILLUSTRATING METHOD OF CHARGING THE FURNACE

Department Arrangement

Unusual care in the various stages of foundry work is required in the construction of high pressure valves. The metal must meet specifications within narrow limits. The valves made in the Chapman plant are poured from steel designated as Class *B* by the American Society for Testing Materials. Even in its initial operation the foundry has borne out the contention of the management in regard to furnishing more satisfactory castings. Under normal conditions the foundry will employ 100 men.

The shop is divided into four main departments: molding, melting, cleaning

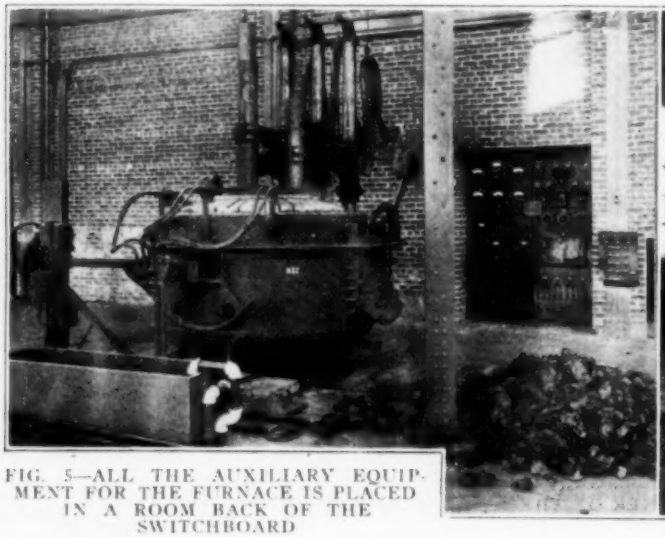


FIG. 5—ALL THE AUXILIARY EQUIPMENT FOR THE FURNACE IS PLACED IN A ROOM BACK OF THE SWITCHBOARD

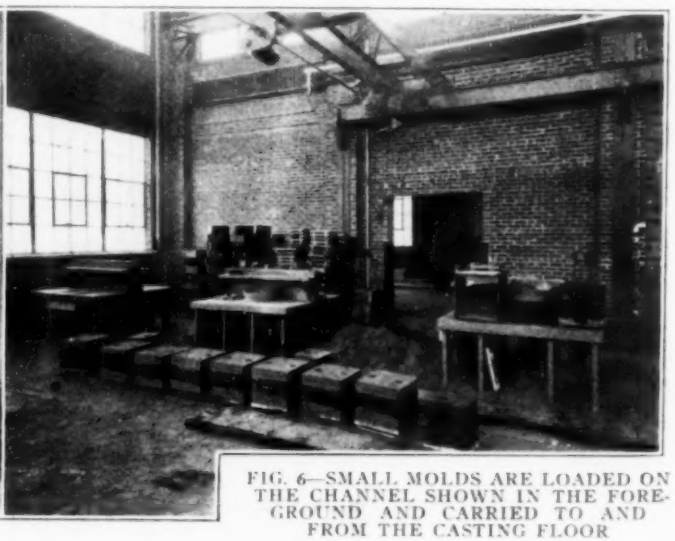


FIG. 6—SMALL MOLDS ARE LOADED ON THE CHANNEL SHOWN IN THE FOREGROUND AND CARRIED TO AND FROM THE CASTING FLOOR

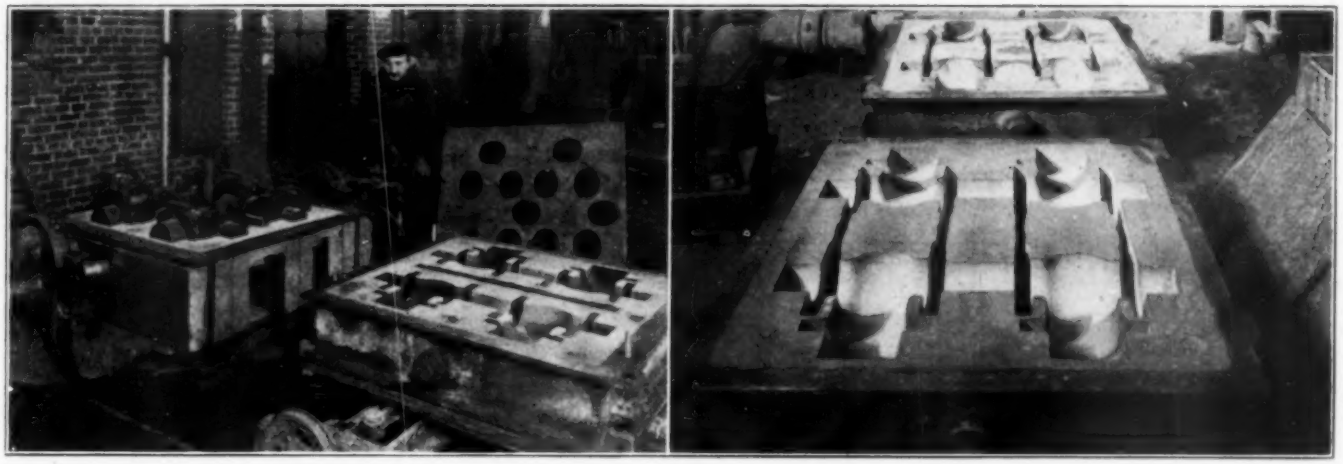


FIG. 7—FOUR VALVE PATTERNS ARE GROUPED ON A SINGLE PLATE, THE PERFORATED PLATE STANDING BACK OF THE FLASK IS CLAMPED ON THE BACK OF THE COPE TO PREVENT THE SAND FROM FALLING OUT WHILE THE SAND IS DRYING FIG. 8—GATING ARRANGEMENT IN THE DRAG

and annealing; and these departments are situated to minimize the handling of materials. However, considerable handling is unavoidable and to make this easier a wood floor has been laid in all departments except that devoted to molding. This floor has been left in the natural state to permit, if necesary the making of large molds in the floor. One end of the molding bay is equipped with three jolt machines and a number of suitable benches for the production of the smaller molds. One corner of this section is shown in Fig. 6. The channel in the foreground is employed for transporting the finished molds from the molding floor to the casting department where they are poured. Two large jar ram machines are located on the heavy molding floor, one of the rollover, pattern-draw type with a table 60 x 60 inches is shown in Fig. 7. The other, provided with a 72-inch table is a plain jolt machine, but is provided with a pattern drawing attachment. Facing sand is mixed in a revolving 6-foot pan where the material is thoroughly blended under a pair of heavy rollers. The pan has a capacity of approximately 30 shovels of facing every 5 minutes. The foundry is served by two cranes as shown in Fig. 3. The upper crane with a lifting capacity of 5 tons, spans the building from side to side, travels the entire length of the foundry and is supported on a runway on each side attached to the building columns. The lower crane has a lifting capacity of 2 tons and is controlled from the floor. It has a traveling range only over that part of the floor devoted to heavy molding. One side of the runway is attached to the building columns in the wall and the other is supported on a row of columns firmly anchored in concrete bases.

Continuous Operation

Melting and pouring are carried on continuously all day. The molds are conveyed to the casting floor, poured from the next ensuing heat thereafter, after which they are shaken out and the flasks and sand returned to the molding floor. The risers are cut off the castings before the latter are placed either in a 10 x 10-foot sandblast room or in a revolving sandblast barrel 6 feet long and 5 feet in diameter. It is stated this is the largest barrel of the kind made. It will accommodate the largest castings the company expects to make, and already has handled castings weighing up to 2½ tons. One section of the cleaning department is shown in Fig. 2. Here the castings are chipped and ground. Full equipment of air chisels, stationary and swing grinders are provided. The stationary wheels piped to an exhaust system, are arranged in a row along one wall close to the windows and a small tumbling barrel shown to the right of the illustration is provided for cleaning the smaller castings. The castings after they have been cleaned, are annealed at a temperature of approximately 1600 degress Fahr. for 3 hours in an electrically heated oven. They then are tumbled to remove and scale and afterward sent to the machine shop.

Other pieces of foundry equipment include an oil and air blast ladle drying platform located near the furnace with piping brought up from beneath the floor

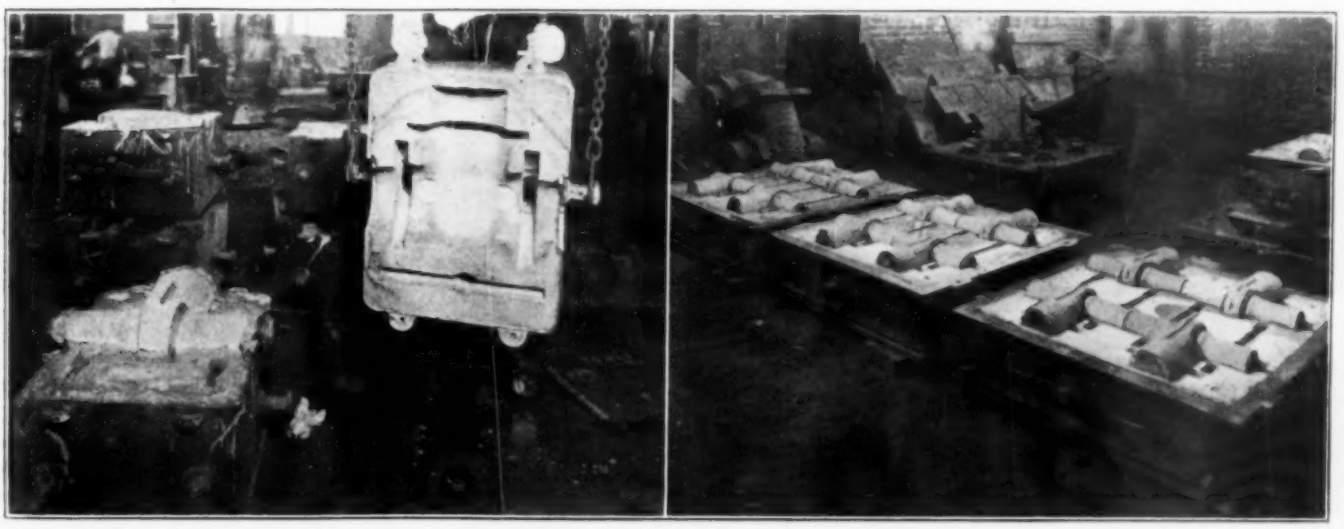


FIG. 9—SPECIAL FLASKS WITH THE SIDES CUT OUT TO ACCOMMODATE THE TWO SIDE PRINTS ARE EMPLOYED FOR MAKING THE LARGER VALVES FIG. 10—ONE CORNER OF THE ASSEMBLING AND CASTING FLOOR

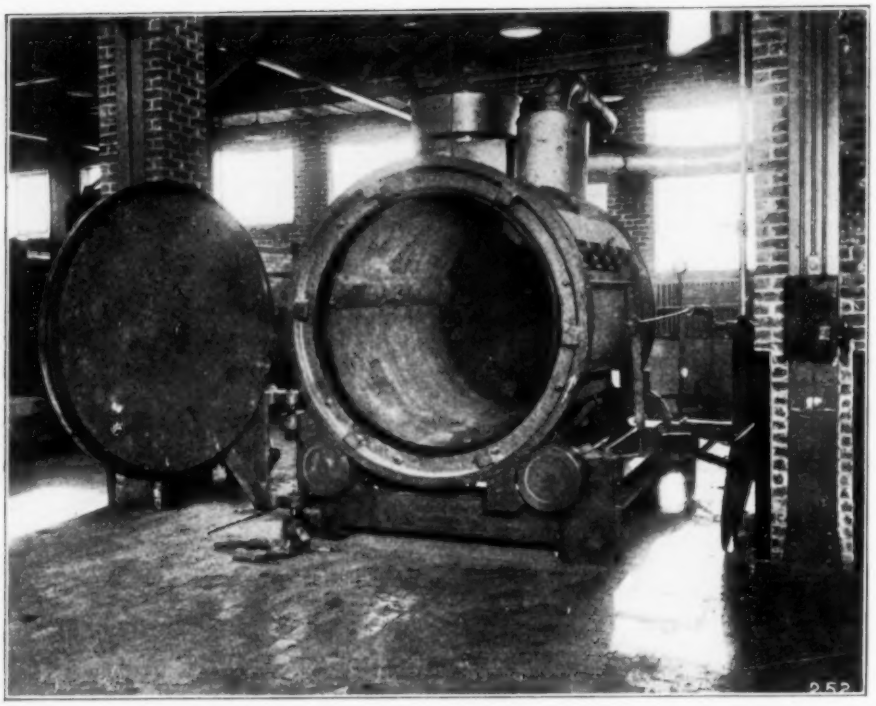


FIG. 11—THIS SAND BLAST BARREL, 6 FEET LONG BY 5 FEET IN DIAMETER, WILL TAKE THE LARGEST CASTING MADE BY THE COMPANY

and, incidentally, this is the only place in the entire foundry where heating or drying of any kind is done by any other agent than electricity. Even in this case the air and oil are pumped by an electrically driven motor. Cracked or faulty castings are repaired with the aid of an electric arc welding outfit located at one end of the cleaning department. Oxyacetylene equipment is provided for cutting risers and other work of that character. The equipment throughout has been designed to suit the special work planned for the foundry.

Molding and core sand arriving on a spur from the main line are unloaded directly into easily accessible bins that extend several feet below the floor level to the base of the building foundation. This arrangement provides extra storage space at reduced cost. It is claimed that these depressed storage bins not only provided extra storage but also furnish an automatic alarm when the sand supply is running low. Whenever the barrow men begin to find the grade too steep leading from the sand bins to the foundry floor, it is time to lay in a fresh supply.

The manner in which the valve bodies are molded is illustrated in Figs. 7, 8 and 9. The mold shown in Fig. 8 is for four standard 8-inch high pressure valves. The cores are shown in the background. Before adopting the present method of mounting four patterns on a plate two men using individual patterns and flasks made 18 molds a day. With the present equipment shown in Fig. 7, comprising a 60 x 60-inch roll over pattern draw machine and four patterns mounted on one plate three men make 15 molds, or 60 castings a day. The ratio between these two methods of operation based upon the number of valve molds per man per day, is 20 to 9 in favor of the four valve flask method; or a little over 100 per cent increase.

The patterns shown in Fig. 7 are grouped symmetrically in relation to a center line on the pattern plate so that both cope and drag molds may be made from the same plate. The gate and runner and also the pads on top of the flanges representing the riser connections, are detachable and only are placed on the plate to form the cope halves of the molds. The method of gating clearly is shown in Figs. 7 and 8. Thus in Fig. 7, it will be noted that the gate attached to a central runner extends almost all the way across the joint. This is the cope half of the mold. The two drags shown in Fig. 8 indicate how the metal from the central runner is conveyed into each individual mold. Deep gates connect opposite flanges and pass directly under the long central gate in the cope when the two halves of the mold are assembled.

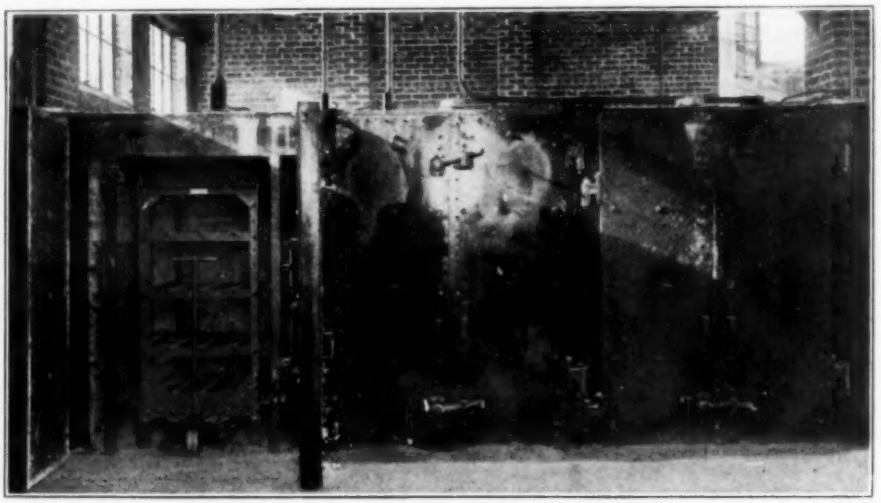


FIG. 13—SMALL CORES ARE LOADED ON RACKS AND CONVEYED IN AND OUT OF THE OVENS ON LIFT TRUCKS—AUTOMATIC THERMOSTAT CONTROL ON ALL OVENS INSURES A CONSTANT HEAT

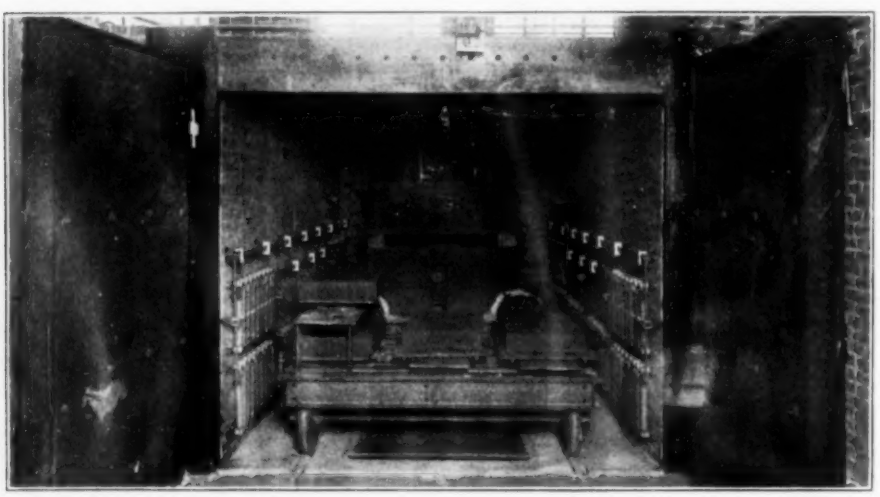


FIG. 12—THE LARGER MOLDS AND CORES ARE DRIED IN THIS ELECTRICALLY HEATED OVEN

The rollover type of machine is particularly adapted to this kind of work inasmuch as neither cope or drag flask is equipped with bars. Had the mold been made in green sand the flask would have to be rigged differently, but in this case where the molds are dried, plain, open flasks render satisfactory service. A plain bottom plate is clamped on the drag flask before it is rolled over, but the special perforated plate shown standing on edge back of the flask in Fig. 7 is employed on the cope. The plate is clamped on the cope before it is rolled over and prevents the sand from falling out of the back. After the mold is dried in the oven it may be rolled back without any danger of the sand falling away from the face. The numerous holes in the plate, of course, are to accommodate the runner and the riser over each flange. In operation two men make the molds on the machine and the third man attends to any necessary finishing including painting the surface with a silica wash.

Electric Oven Used

The molds are loaded on a car and dried in the oven shown in Fig. 12. In this electrically heated, automatically controlled oven, the temperature is raised to 450 degrees Fahr. after the molds are placed inside. It is held at that temperature for 4 hours and then the molds are taken out, assembled and poured. Molds that have accumulated in the meantime are loaded on the car and placed in the oven today. A considerable number of the smaller castings are poured in green sand molds. Cores are made in a room adjacent to the main foundry floor and baked in a battery of electrically heated core ovens of the type shown in Fig. 13. Automatic thermostat control in these ovens maintains a temperature within close limits.

One section of the floor on which the molds are assembled for pouring in the vicinity of the furnace, is shown in Fig. 1. In Fig. 9, a man is shown in the act of closing a large valve mold. The mold is made in an individual flask cut out at both sides to accommodate the two side prints, but it will be noted that the same gate arrangement is employed as that shown where four valves were molded in one flask. A gate is cut into each of two flanges in the drag and a channel in the cope connected to an upright runner supplies the metal to both gates at the same time. The riser distribution on the cope also is similar to that shown in Fig. 7. Approximately one third of all the metal melted goes into gates and risers.

The electric furnace shown in Fig. 5, has a capacity of 2 tons to a heat and 6 heats in 10 hours. It is rated by the manufacturers at 550 kilowatts per ton of steel melted. Nearly all the auxiliary equipment of this furnace, transformers, switches, operating motors, etc., are contained in a separate room back of the switchboard shown to the right in the illustration Fig. 5.

Replacement Provided

To guard against emergency in electric furnace operation, it is advisable to have an extra furnace roof stored near at hand. However, the usual problem connected with an arrangement of this character is to find a place to store the extra roof until it is wanted. In this instance a platform about 10 feet above the foundry floor, has been erected near one end of the building, large enough to support the spare furnace roof. In this manner all the floor space is available for its legitimate purpose and yet the alternate cover always is on hand and ready.

The method and equipment employed in charging the furnace are shown in Fig. 4. Long, narrow charging pans, open at one end; mounted on wheels and provided with means for lifting by the crane are loaded in the scrap yard and brought in on a hoist suspended from a monorail which terminates directly above the charging door of the furnace. Each pan has a capacity of one ton or approximately half the melting capacity of the furnace. As shown in Fig. 4, the open end of the pan is inserted in the charging door opening in the furnace. The material is distributed evenly over the bottom of the melting chamber by tilting the furnace at the same time the hoist tips the pan to discharge the contents into the furnace. Scrap of a uniform analysis is obtained from a nearby plant, one of the contributing factors, as already stated, leading to the erection of the present steel foundry. The scrap yard is equipped with a magnet hoist.

Uniform Scrap

Return scrap, gates and risers are charged on the bottom of the furnace and then fine scrap is dumped in and raked over to fill the crevices between the pieces of larger material. The material forming the charge is of such a uniform composition that it seldom is necessary to add anything further to bring the metal to the desired analysis. However, each heat is carefully checked. Tests are taken in the usual manner and analyzed in a well equipped laboratory located close to the foundry building. The melter judges the temperature by spilling the contents of a test ladle on the floor and noting its fluidity. When the heat is ready the furnace is tilted and the contents poured into a large ladle and a certain part of the metal in the large ladle is transferred to single shanks used to pour the smaller castings. Large ladles of the tea pot type are provided for pouring the larger castings.

Equipment Installed in Valve Foundry

One 2-ton electric melting furnace with a power consumption of 550 kilowatts per ton, made by the Pittsburgh Electric Furnace Co., Pittsburgh.

Three small plain jolt and one large jolt, rollover, pattern-draw molding machines, made by the Osborn Mfg. Co., Cleveland, and one large jolt machine made by the Tabor Mfg. Co., Philadelphia. A pattern drawing device made by the Herman Pneumatic Machine Co., Pittsburgh, is used.

One 6-foot facing sand mixer made by the National Engineering Co., Chicago.

One sand blast barrel 6 feet long, 5 feet in diameter, made by the Standard Equipment Co., New Haven, Conn.

Direct connected air compressor with a capacity of 1040 feet free air per minute, made by the Ingersoll-Rand Co., New York.

One 5-ton crane, 50-foot span, made by the Shaw Electric Crane Co., New York.

Two cranes made by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., one a 2-ton floor controlled crane in the molding bay of the foundry and the other a 3-ton cage controlled hoist charging.

Three swinging grinding machines each equipped with a 24-inch wheel and operated by a 15-horsepower motor, manufactured by the Excelsior Tool & Machine Co., East St. Louis, Ill.

Electric annealing, mold and core ovens, manufactured by the American Industrial Furnace Co., Boston.

A 10 x 10-foot sandblast room and tumbling barrel, made by the W. W. Sly Mfg. Co., Cleveland.

Ladles and miscellaneous equipment, manufactured by the Whiting Corp., Harvey, Ill.

Equipment Firm Buys Manufacturing Plant

F. A. Coleman, former vice president and general manager of the Foundry Equipment Co., Cleveland, has been made president and general manager of the F. A. Coleman Co., engineers and manufacturers of foundry equipment. The Coleman company has purchased the plant of the Advance Engineering Co., 6539 Metta ave., Cleveland. This company has completely equipped blacksmith, structural and machine shops and is engaged in the manufacture of clam shell buckets, which the F. A. Coleman Co. will continue as a part of its line of foundry equipment.

Cost Association Meets

The Industrial Cost association held a meeting in New York, May 18. The question of reducing the costs of products was discussed. H. D. Starr is secretary of the association which has executive offices at 50 Church street, New York.

Influence of Graphite on Iron

Theories Advanced for the Varying Effects of Graphite on Cast Iron and Semisteel Explain States in Which It Is Found—Causes Are Analyzed—Micrographs Illustrate Points

BY J. W. BOLTON

ORIGINAL research in foundry metallurgy must go deeper than it has done in the past if the intricate problems of the foundry are to be solved. The article presented here by Mr. Bolton shows scientific accuracy coupled with a vision of the problems of the iron foundry. He has indicated many important facts some of which are entirely new. Among these are that—

Sulphides occur in graphite flakes.

It is quite likely graphitization of gray iron proceeds below the transformation range.

Graphitization may be regarded from the kinetic, or energy, viewpoint.

Cooling time has much more influence on graphite size than composition.

Grain growth of graphite is influenced by difference in graphite size, rate of cooling, presence of accelerating, or obstructing, agents in intermediate layers.

Sulphur may occur in iron as SO_2 gas.

The high physical properties of semisteel are largely due to cumulative effect of certain factors which are enumerated.

The author also describes a new metallographic method by which the action of the reagent may be studied while in effect. In addition much accumulated information has been arranged to give a clearer view of the subject.

SUCCESS in industry depends ultimately upon application of scientific principles to all business problems. The progress of civilization has accelerated at the same rate that men began to reason cause and effect and to discard *rule of thumb* methods. To find causes it is necessary to get down to fundmaentals, to the foundations of the structure. The study of gray iron is no exception.

*Manuscript submitted March 14, 1922.

Fig. 1—Composition—Silicon, 1.40 per cent; sulphur, 0.090 per cent; phosphorus, 0.50 per cent; manganese, 0.55 per cent; total carbon, 3.55 per cent—Mixture consisted of steel rails, 10 per cent; carwheels, 5 per cent; foundry and commercial scrap, 25 per cent; remainder machine-cast pig iron—Sample taken from center of a slab ⅜ x 4 x 10 inches as cast—Note small graphite particles showing rounded ends of vertically inclined flakes, also variations in sizes of flakes—Unetched—X 100 dia.

Ordinarily gray iron has four major structural constituents, graphite, pearlite, ferrite, and steadite. This article deals with graphite, telling what it is, how it is formed, and what influences it has on the physical properties of the gray iron. This exposition is not complete, either in scope or in detail, but the writer has presented what he considers the major facts.

All foundrymen have seen evidences of graphitic structure. The graphite in the metal gives gray iron its color and much of its brittleness. A pig iron, or a casting, with high graphite has a dark, open grain, or coarse fracture. Graphite is sometimes seen as kish on top of ladles of high-carbon high-silicon iron. In malleable iron the white castings in which practically all of the carbon is combined with the iron, are annealed until the carbon separates out in a modified form of graphite, called temper carbon, and the fracture is changed from white to gray.

Free Carbon in Nature

Elementary or free carbon exists in nature in three forms; the diamond (hard crystalline); graphite or plumbago (soft, crystalline or amorphous); and as the so-called amorphous carbon (soot, lamp black, etc.). Gray iron can be synthisized from iron and any of these forms of carbon. The mineral graphite (plumbago), when crystalline, generally is found in the hexagonal system. This is referred to later when discussing the forms of graphite in iron.

Until comparatively recent times graphite in gray iron has been considered as practically pure free carbon. Osmond and Stead, Desch, Gulliver, and others refer to graphite as pure carbon. While this conception has served a useful purpose it is not strictly in accord with demonstrated facts. These facts show that the graphite flakes of gray iron are a conglomerate structure containing carbon, ferrite, gases, and sul-

Fig. 2—Composition—Silicon, 1.76 per cent; sulphur, 0.136 per cent; phosphorus, 0.48 per cent; manganese, 0.41 per cent; total carbon, 3.02 per cent—Mixture consisted of steel scrap, 20 per cent; foundry scrap, 40 per cent; pig iron, 40 per cent. Sample taken from a 1⅛-inch test bar iron improperly melted—Shows medium graphite seemingly heavily distributed—Unetched—X 100 dia.

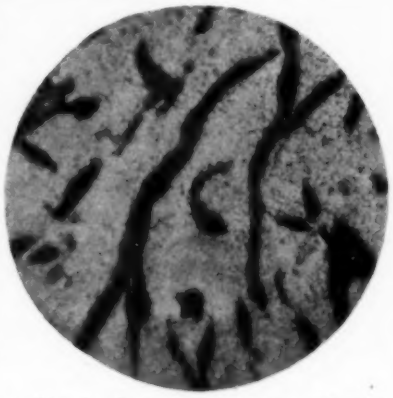


Fig. 3—Same composition and mixture as Fig. 1—From middle of a bar 4 x 4 x 10 inches—Slower cooling has promoted graphite growth.

phides. (See Figs. 4 and 5). Therefore, although graphite is largely free carbon, its other components may exert considerable influences on the properties of the metal.

Much of the information which foundrymen have on graphite is misleading. This is due to three primary reasons: First, sampling is often wrong; second, sometimes analyses for graphitic carbon are erroneous; third, physical properties, due in part to the amount and distribution of combined and graphitic carbon, often are assigned wholly to other causes. Illustrations are given in the following paragraphs.

Published ratios of combined and graphitic carbon rarely give sufficient data so that results can be duplicated by other investigators. For examples, section sizes are not mentioned, pouring temperatures are not given, and size of mold, permability of sand to heat, etc., are left to the imagination.

Two points in analytical methods which are frequently used may lead to errors in research work. They are the direct weighing of graphitic carbon, and the decomposition of the iron by hydrochloric acid. The first cannot be relied on in all cases because of the difficulty of washing the graphite free from iron and from substances such as titanium oxide, aluminum silicate, etc., which are not easily soluble in acids or alkailies. The second method, that of using hydrochloric acid for dissolving the sample gives high results. The experience of the laboratory force of the Niles Tool Works Co., Hamilton, O., of which the writer has charge, has been that when using hydrochloric acid and water for solution of the metal and washing the graphite, results were 0.05 to 0.15 per cent too high. Also, the addition of hydrochloric acid to the nitric acid usually used for graphite carbon determinations causes high results. In this connection it is interesting to note that direct solution of high-carbon steels, microscopically free from graphite, sometimes leaves a carbonaceous residue.

Fig. 5—Composition—Silicon 1.75 per cent; total carbon, 3.30 per cent; combined carbon, trace—Heat tinted until first color showed purplish at edges of steadite, ferrite brown under microscope—From center of bar 4 x 4 x 10 inches—Note network in graphite—X 100 dia.

The correct method is to use nitric acid and potassium or sodium hydroxide, as detailed in the data sheets of THE FOUNDRY of Feb. 15 and March 1, 1922.

Beneficial Results Questionable

Results have been published to show the effects of various metals and metalloids as scavengers and degasifyers. These data do not give the combined or graphitic carbon, the effects being assigned to the additions. Inasmuch as certain of these metals and metalloids increase the combined carbon the assignment of all beneficial result to these *dopes* is rather questionable.

Since exact knowledge of the formation of graphite can be worked out only by the extension of knowledge of certain parts of the iron-carbon diagram, Fig. 18, consideration of this diagram is in place here.

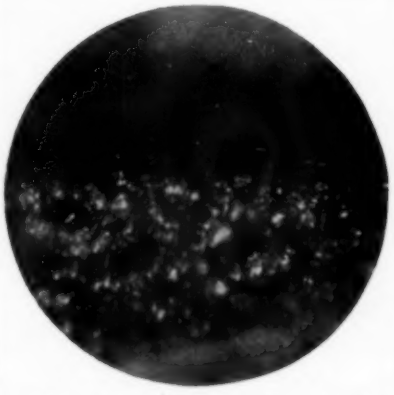


Fig. 4—Graphite flake showing network—Heat tinted—X 700 dia.

Fig. 6—Oxidized iron in churned riser—Silicon, 1.57 per cent; sulphur, 0.48 per cent. Note sharpness of graphite flakes and many small dots.

This diagram represents pure iron-carbon alloys. All above the line LEL is liquid. The triangles LSE and L S E represent regions of partial solidification. Below LSES' is solid. For all ordinary gray iron work one is concerned only with the region between 2.5 per cent and 4.5 per cent carbon. This liquid solution lying above LEL has been generally considered a solution of gamma iron and cementite*. Cementite was supposed to exist in solution in the molecular form. However, recent researches, notably those using the methods of X-ray analysis have inclined many investigators toward the view that this carbon exists in solution in the atomic form, even in the solid solution**. The solid solution of iron and carbon as it exists above the transformation range CDF is known as austenite.

*Gamma iron is an allotropic form of iron stable at high temperatures and nonmagnetic. Alpha iron is the allotropic form stable at low temperatures. Beta iron is a supposed allotropic form stable between the gamma and alpha iron. Many authorities deny the existence of beta iron. Cementite is an iron carbide of the formula Fe_3C.

**Jefferies and Archer, the Slip Interference Theory of Hardening Metals, Chem. and Met. Eng., Vol. 26, No. 6, p. 249, gives a summation of the principal viewpoints.

Fig. 7—Cross section shape of graphite flakes—Unetched—X 100 dia.

When, on cooling, the temperature of the metal has reached the line LE, crystals of saturated or primary austenite commence to separate. This separation continues at gradually lowering temperatures until solidification of the eutectic ledeburite*, at the point E. If the carbon content is to the right of the point E; that is, over 4.3 per cent and cooling below EL, primary cementite continues to solidify at decreasing temperatures until the point E is reached and ledeburite separates.

On slow cooling below SES cementite is progressively liberated from the austenite which thus becomes poorer and poorer in carbon until about 0.85 per cent combined carbon is reached at 700 degrees Cent. At this point the remaining austenite is converted into pearlite. Thus in hypoeutectic irons there are three sources of cementite carbon: From the cementite of the eutectic; from the pro-eutectoid liberated from the austenite; and the cementite of the pearlite.

Fig. 8—Illustrating orientation and cross section shape of graphite flakes—etched with Steads reagent—X 100 dia.

Cementite** is a mestable form or a form with *greater internal energy* than the stable forms, iron and carbon (graphite), of which it consists. On slow cooling, both eutectic and pro-eutectoid cementite (or the solid solution of iron and carbon) tend to decompose into their more stable constituent.

Discussion of the double equilibrium diagram is omitted, partly to avoid confusion and partly because it does not seem justified by the experimental facts.

The fact that graphite is the most stable form of carbon in the iron is both a blessing and a curse to the foundryman. If it were not for graphitization all cast iron would be white iron. If graphitization proceeds too far the iron becomes soft spongy and open grained and loses its strength. The big problem in producing gray-iron castings is to control the amount and quality of graphitization.

The formation of graphite may be considered to be always preceded by the formation of cementite, or as occuring by direct separation of carbon from solid solution. In the former case the formation is represented by the equation:

$Fe_3C = 3\ Fe$ + graphite + energy.

The major reaction proceeds toward the right according to the general rule of physical chemistry that exothermic reactions proceed toward completion.

In the latter case direct separation of carbon takes place from the supersaturated solid solution. It is well to note here that from the kinetic point of view all reactions are reversible, although the reverse action may be extremely slow. This conception will account for both the formation of graphite itself and the phenomenon of graphite growth.

In pure iron-carbon alloys the actual formation of graphite starts just after solidification along SES (1130 degrees Cent.). It is not definitely known at just what temperature graphitization ceases. The major portion of the graphite formed on moderately rapid cooling probably separates between SES and about 1000 degrees Cent. The rate of graphitization decreases directly with the temperature. The *rate* of cooling also becomes slower as the temperature lowers. Thus a long time at a lower temperature might produce graphitization equal in amount to a short time at a higher temperature. All foundrymen have noted that slow cooling promotes graphitization.

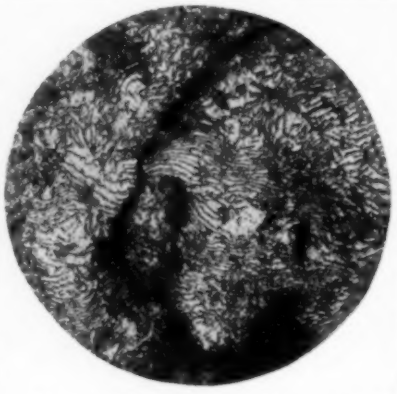


Fig. 9—Gray iron with eutectoid matrix—The pearlite laminal are rather small—No steel used in the mixture—etched with picric acid—X 600 dia.

This *primary* graphitization frees the carbon which on very rapid cooling from SES would be in the eutectic and pro-eutectoid cementite. In castings of small section this primary graphitization is the only one which takes place in any considerable degree. Hence the matrix of the metal; that is, irrespective of graphite and steadite, is of *eutectoid* composition, as indicated by Fig. 9. This is all very well and such an iron is good insofar as its matrix is concerned However, slow cooling, as in a heavy section, produces a different condition of affairs, as shown by Fig. 10. Graphitization has not stopped with the carbon of eutectic and pro-eutectoid cementite. The pearlite is lessened and there are broad bands of ferrite along the graphite flakes. This is an undesirable condition where the best physical properties are desired.

Fig 10—Ten per cent semisteel—Sample from center of 4 x 4 inch section—Note ferrite along graphite flakes—Etched with Picric acid—X 44 dia.

We do not know where this graphitization of austenitic carbon or of pearlitic cementite ceases. The more common assumption is that this transformation stops at a temperature corresponding to the change of austenite to pearlite, indicated by the line *CDF* on the iron-carbon diagram. According to this view the austenite loses carbon until at *CDF* it is not of eutectoid composition. That is, it is a solid solution containing less than 0.85 per cent combined carbon, in which case, on passing below *CDF*, it gives ferrite and pearlite. While such a reaction may and probably does take place the writer believes that in commercial irons cast in heavy sections there is another reaction which accounts in part for the final state of affairs shown in Figs. 10, 11 and 12.

Several reasons exist for believing that there can be graphitization (of pearlitic cementite) below the transformation range. Such graphitization probably takes place when the rate of cooling is very slow.

R. S. Archer has shown that in white

*Ledeburite is an eutectic of cementite and austenite.

**Pearlite is an eutectoid (a mechanical mixture of constant composition and laminar structure) of ferrite (pure iron practically free from carbon) and cementite.

cast iron graphitization* can be initiated and completed below the transformation range, *CDF*. The presence of free carbon tends to promote the formation of more graphite. Therefore, irons which could be graphitized below *CDF* if cast white, on slow cooling, would probably graphitize the pearlitic cementite the more readily because of the added influence of the graphite already formed from the eutectic and pro-eutectoid cementite.

If all graphitization is assumed to occur above *CDF*, it would be reasonable to expect a somewhat different distribution of pearlite than occurs in commerciol hypo-eutectoid irons. In slowly cooled castings the large graphite flakes are surrounded by broad bands of ferrite, then sharply outlined areas of pearlite.

These ferrite bands are very often over 0.002 inch wide on each side of a graphite flake. If carbon is taken from the austenite above *CDF*, the matrix would be progressively richer in carbon as the distance from any graphite flake is increased.

Since decomposition of cementite gives iron (ferrite) as well as graphite there must be considerable ferrite around and

Fig. 11—From a ferritic area in the same sample as Fig. 10—Ferrite and graphite are shown—Etched with picric acid and alcoholic solution with 5 per cent nitric acid—X 300 dia.

in each graphite flake. The decomposition of pro-eutectoid and eutectic cementite should give (by volume) about three ond one-half times as much ferrite as graphite carbon. This ferrite is not usually plainly evident in micrographs because some of it is embedded in the graphite flakes and part of it is probably covered over in the polishing operation. The graphitization of carbon which would otherwise occur as pearlitic carbon should give about thirty parts of ferrite (by volume) to each part of graphitic carbon. In practice the ferrite envelops surrounding large graphite flakes are often over twenty times the area (in the plane of the specimen face) of the graphite flakes. Even in these broad bands the lines of demarkation of pearlite, ferrite, and graphite are sharp.

The black graphitic flakes occuring in gray iron and semisteel are mixtures. The major constituent, in point of

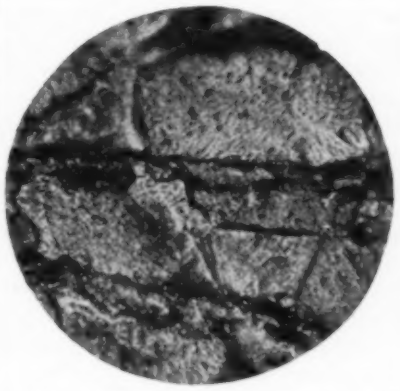


Fig. 12—Ferrite and graphite. The grain boundaries of the ferrite are eaten out deeply and the ferrite is slightly attacked—Etched deeply with picric acid and a 5 per cent nitric acid alcoholic solution—X 300 dia.

volume, is graphitic carbon. This carbon possesses the same properties as natural graphite. For example, Jokibe* prepared graphitic carbon from gray iron by dissolving off all other substances in acids. The carbon remaining was pressed into cylindrical rods and examined by X-rays. The X-ray photographs show that graphitic carbon in gray iron is identical with natural graphite.

Graphite flakes also contain ferrite. Under high magnifications suitably prepared samples show a bright irregular network with dull rounded spots here and there, Figs. 4 and 5. The network consists largely of ferrite left from the decomposition of cementite.

Graphite is known to hold some gases. Reversible changes in volume much below the critical range have been attributed to the presence of such gases. After considering the large gas absorbing powers of carbon in such forms as charcoal the idea that the graphite flakes are gas absorbents should not seem unreasonable.

The question of sulphur in the iron has interested foundrymen for many years. Our knowledge of the distribution and states of sulphur in iron are imperfect. Most authorities contend that the great majority of sulphur in gray iron occurs as manganese sulphide, MnS. This manganese sulphide is said to be found as small rounded particles which appear dove colored on picric acid etching and are distributed through the pearlite and ferrite. If the majority of sulphur occurs in the form of MnS, it is very finely divided because it is not always seen in specimens with ordinary amounts of sulphur. The writer feels that, irrespective of the state of division and the distribution of manganese sulphide, manganese exerts a decided influence on the properties imparted by sulphur. Some writers claim that sulphur in the iron which is residual from the pig is not harmful, but that absorbed from the coke is harmful. It may be pointed out that sulphur from the coke is absorbed largely as iron sulphide. The writer has shown* that under cupola conditions it is probable that some sulphur oxides are formed in the metal.

Sulphur An Influence

It has been known for some time that sulphur has an influence on graphite grain size. The laboratory of the Niles Tool Works Co. has conducted some research to determine what relations might exist between sulphur and graphite.

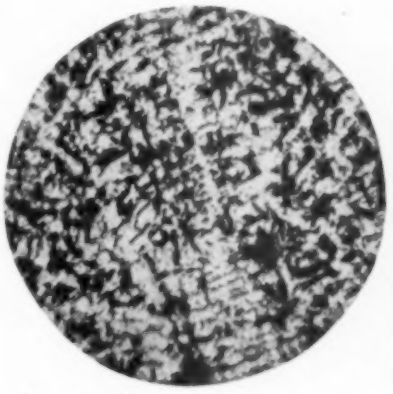


Fig 13—Note the lines passing through the graphite. Although this phenomenon occurs in ordinary castings, it often seems more pronounced when the piece has been stressed. This bar was held 50 hours at 3000 pounds transversed pressure and 0.115 inch deflection. It was broken under a 4020 pound load at a deflection of 0.125 inch. Unetched—X 50 dia.

One fact clearly demonstrated is that *sulphur in the sulphide forms actually occurs* in the graphite flakes. Several ways of proving this have been developed. Fig. 14 illustrates the most striking one. To obtain this reaction a carefully polished specimen is treated with a 2 per cent aqueous solution of syrupy

*Graphitization of White Cast Iron, reprint in THE FOUNDRY, March 1, 1920, original paper presented before New York meeting of American Institute of Mining & Metallurgical Engineers, February, 1920.

*Kei Jokibe, Science Reports, Tohoku Imperial University, Vol. 9, pp. 275-279 (1920).

*How Slags Affect Cupola Operations, THE FOUNDRY, Sept. 1, 1921.

phosphoric acid. It is then placed under the microscope with the layer of acid adhering. Bubbles rise *from the graphite flakes only*. This action progresses for a long while before any etching of the metal matrix occurs. The gas evolved is hydrogen sulphide, which has the characteristic smell of the uncontaminated gas. The gas generated by dilute hydrochloric acid has a different odor. It probably contains phosphides and carbon-sulphur compounds.

It is quite possible that other substances, besides those enumerated, may occur admixed in the graphite flakes. To sum up, graphite contains:

Graphite carbon from decomposition of cementite or precipitation of carbon from solid solution:

Ferrite left from this decomposition:

Gases which are absorbed before and during solution:

Sulphur as sulphides, probably occurring as mechanical neucleii and finely divided.

Fig. 14—From a hypo-cutectoid gray iron covered and photographed through a layer of diluted phosphoric acid, (Yellow filter, 30 seconds exposure, Eastman commercial film, 8 mm. achromatic objective)—Note bubbles of hydrogen sulphide rising from graphite flakes—X 100 dia.

The influence of silicon in accelerating graphitization is well known to foundrymen. Foundry metallurgy owes its greatest strides during the past twenty-five years to the discovery that silicon content is a better basis for grading than the fracture method. In present day practice the amount of silicon in the iron is the major determining factor considered by the foundryman when preparing his mixture.

It is commonly held that silicon promotes decomposition of cementite by decreasing its stability. Silicon also lowers the amount of carbon required to give the eutectic indicated by *E* in the diagram. Sauveur* states that from the work of Wust and Peterson we may expect that each per cent of silicon lowers the amount of carbon required for the eutectic some 0.30 per cent. Thus 2 per cent silicon and 3.7 per cent carbon should give the eutectic alloy. Silicon raises the *CDF* transformation line about 50 degrees Cent. for 1.0 per cent silicon.

Total carbon has an important influence on the degree of graphitization. While this influence can be seen in everyday practice it is doubtful whether many foundrymen make use of it. To take two extreme illustrations; high-carbon steel is graphitized only with difficulty, while it is hard to produce high-carbon irons completely free from graphite. Applied to everyday foundry practice, for a given section lower-silicon iron higher in carbon will give approximately the same physical properties as are obtained by a higher-silicon, lower-carbon mixture. This is a reason why the silicon content one foundryman may have found good gives another foundryman either hard or open-grained castings, as the case may be.

Various workers claim that graphitization occurs more readily in the presence of certain gases. For example, Honda and Murakami* claim that graphitization is favored by the presence of either carbon monoxide or dioxide. The carbon monoxide is most readily formed from carbon and iron oxide occuring in the metal. Their hypothesis is that these gases exert a catalytic action according to the equations

$$2\ CO = CO_2 + C$$
$$Fe_3C + CO_2 = 2\ CO + Fe$$

Sulphur is known to oppose graphitization as well as to have a tendency to lower the graphite flake size as indicated by Figs. 6 and 16. Some claim this is due to stabilization of cementite, while others speak of sulphur *envelopes* which mechanically hinder graphite growth. The illustration, Fig. 16, represents an exceptionally high-sulphur iron, heat tinted. This iron was apparently oxidized. Heat tinting caused the blue *envelope* formations around the graphite flakes.

Manganese, of itself, hinders graphitization by the formation of iron-manganese double carbides, or of manganese carbides which are more stable than iron carbide. This effect is not noticeable in the general run of gray-iron castings with 0.50 to 0.80 per cent manganese. In such irons considerable manganese occurs as the sulphide. The effect of manganese in the higher-manganese high-carbon semisteels may impart to them a proportion of their higher physical properties. Although high manganese tends to form more combined carbon it also increases the carbon dissolving powers of the metal.

Phosphorus apparently has no direct effect on graphitization. The fluidity imparted by high phosphorus may have some effect in allowing low pouring temperatures. Complete information on the effects on graphitization by the less common elements is not available. It seems that chromium, copper, zirconium, and cobalt hinder graphitization and nickel promotes it.

Physical Factors Important

Some physical factors affecting graphitization are of great practical importance. However, little attention is paid to them in many foundries. The controlling factor is the rate of cooling through the graphitization range. Physical subfactors are those which affect the rate of cooling. The main ones are:

Fig. 15—Same iron as Fig. 10 but cast in smaller section—Note more pearlite, less steadite, and small graphite; the latter as fine gray threads where the flakes were—Etched with picric acid—X 44 dia.

Melting temperature, which influences the pouring temperature, which influences the rate of cooling.

Heat conductivity of the mold—chills produce quick cooling.

Time castings are taken out of the sand; if still above graphitization range.

Section size of casting, which is probably the major subfactor.

For the majority of work the terms section size and rate of cooling are, for practical purposes, synonymous. Little data of practical working value is available on the first four factors listed. In regard to section size, experiments in the laboratory of the Niles Tool Works Co. indicate that composition and section size are about equally important when per cent graphitization is concerned, and that section size is the major factor governing graphite flake length.

For example, an iron containing about 1.75 per cent silicon and 3.30 per cent total carbon, cast into a bar 1⅛ inches

*Metallography and Heat Treatment of Iron and Steel.

*Graphitization of Iron Carbon Alloys, Science Reports, Tohoku Imperial Unio., Vol. 10, No. 4, p. 273.

Fig. 16—Heat tinted to general brown—Same sample as Fig. 6—Many light blue spots, especially along graphite—These probably are sulphide envelopes—It does not seem probable they are oxide areas, as oxides generally heat tint differently—X 500 dia.

in diameter, which produces 0.45 to 0.50 per cent combined carbon, will give over 20,000 pounds per square inch tensile. The same iron cast into a bar 4 inches in diameter and slowly cooled will give, in a 1-inch diameter test bar taken from the center of the cylinder, only 10,000 to 15,000 pounds per square inch tensile strength, and around 0.20 per cent combined carbon. These data show in a measure what the effect of section size may be on the strength of the iron.

Separation of Graphite

Under the discussion of pure iron-carbon alloys in this article it is stated that graphite separates either by decomposition of cementite which has formed, or by direct separation of carbon from the iron-carbon solid solution, or both. It is also pointed out that it is possible that graphitization continues below the A_1 transformation range, especially in case of commercial gray-iron castings cooled slowly. It seems to the writer that the various theories on the states of carbon in the iron are in large part reconcilable when viewed from the energy point of view. During solidification, and in fact always, the various constituents of the metal are in a state of kinetic equilibrium. The state of greatest thermodynamic stability is reached when all proximate substances have changed to forms of least possible internal energy content. Complete change to the most stable forms of matter necessitates enough kinetic energy to bring all variant particles into contact and abstraction of enough heat energy to allow thermodynamic dedregation of energy. Take carbon in liquid or in solid solution in iron, and therefore in a state of kinetic equilibrium with it; owing to the atomic attractions between iron and carbon at any given instant some cementite would be present. But this cementite molecule would not hold the same carbon atom continuously—there would be a continuous interchange, some atoms being held while others are free. Therefore, there must be both free atomic carbon and cementite in the liquid or in the solid solution.

Graphite, the most stable form of carbon in iron, is not readily soluble in ferrite at low temperatures. Thus, on cooling, iron becomes less able to hold carbon in solution. When the first free carbon has separated out, from the supersaturated solution, presence of the first graphite flakes or neucleii accelerates subsequent formation of graphite. This first separation of free carbon may become carbon neucleii because the limits of supersaturation have been passed due to such mechanical neucleii as sulphide particles or because of the catalytic action of gases.

To illustrate, consider the carbon atoms in solution moving slower and slower as their kinetic energy decreases (the metal cools). At a certain point, the saturation point, the kinetic energy of the atoms just balances the crystallization forces acting upon them. Just below this point crystallization starts, since the crystallization *pull* overbalances the kinetic energies of the various atoms. Then in the neighborhood of these crystal neucleii the crystallization forces are more concentrated and the crystals grow faster and faster at the expense of the

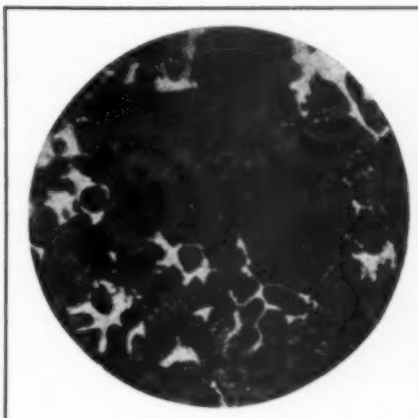


Fig. 17—Same sample as Fig. 10—Note large dove-colored inclusions of manganese sulphide— Etched with picric acid—X 100 dia.

atoms. In growth from the atomic state of division to the coarse graphite flakes the free carbon flakes must pass through all sizes. Therefore, some graphite flakes may exist in the cooled metal in the colloidal state.

Graphite Growth

The phenomonon of graphite growth is important industrially as it affects the strength and finish of the machined iron. The rate of cooling is the major factor affecting graphite growth. Explanation of this phenomonon again brings to the front the question of kinetic equilibrium. Kinetic changes in metals at room temperatures are phenomena familiar to metallurgists. Cast iron considerably below its melting point cer-

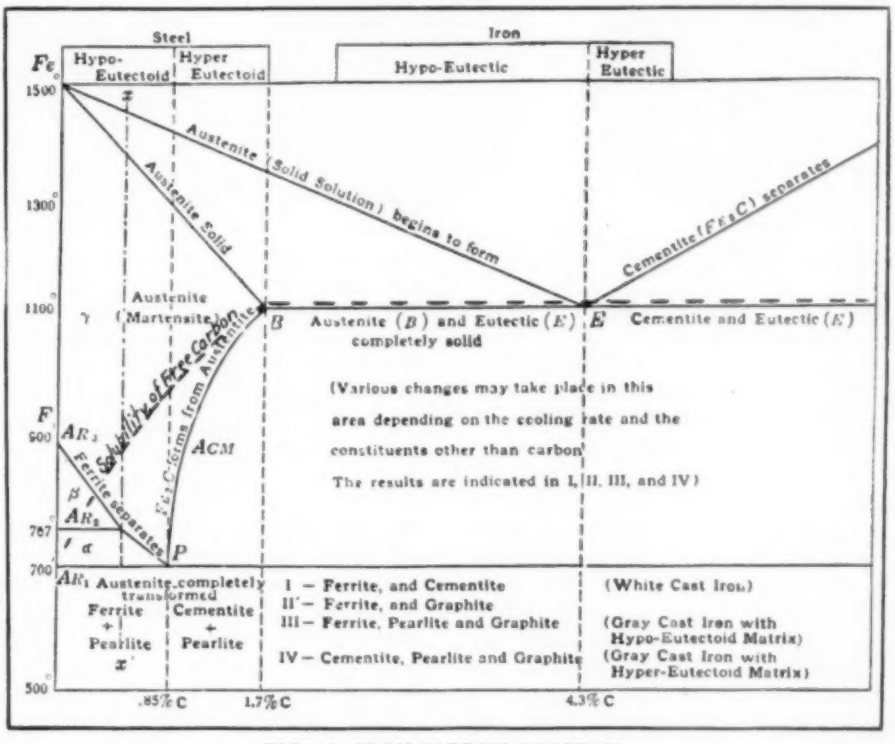


FIG. 18—IRON-CARBON DIAGRAM

tainly does not seem a highly mobile metal. Remarkable arrangements of graphite in stressed specimens have been noted in this laboratory as shown by Fig. 13. However, similar structures have sometimes been noted occurring in unstressed (unless in cooling) specimens. The writer wishes only to point out the possibility of graphite movement at low temperatures. No distortion or peculiar arrangement of pearlite or steadite has been noted. The arrangement of graphite shown in Fig. 13 bears some resemblance to some eutectic forms.

from the smaller to the larger flake because, for equilibrium in the solution itself, dispersion must be uniform. This carbon gradient is not steep because of the small amount in the ferrite, but it is enough to permit the reaction. This tendency for solution equilibrium and the crystallization and kinetic forces in the graphite flakes themselves will ultimately cause absorption of all the smaller flakes by the large ones. The conditions necessary are; variation in the sizes of the original flakes; high enough temperature to permit carbon migration; the presence

and there is a continuous movement of carbon toward the graphite flake. In this case graphitization would not necessarily cease at the A_1 point (the lower transformation range) but would continue as long as there is sufficient motion of carbon atoms.

On many micrographs of unetched gray iron the graphite seems to occur as flat curved plates all lying in the same plane. As these micrographs are made from specimens placed in various orientations, one should expect the graphite flakes to run in all directions. As a

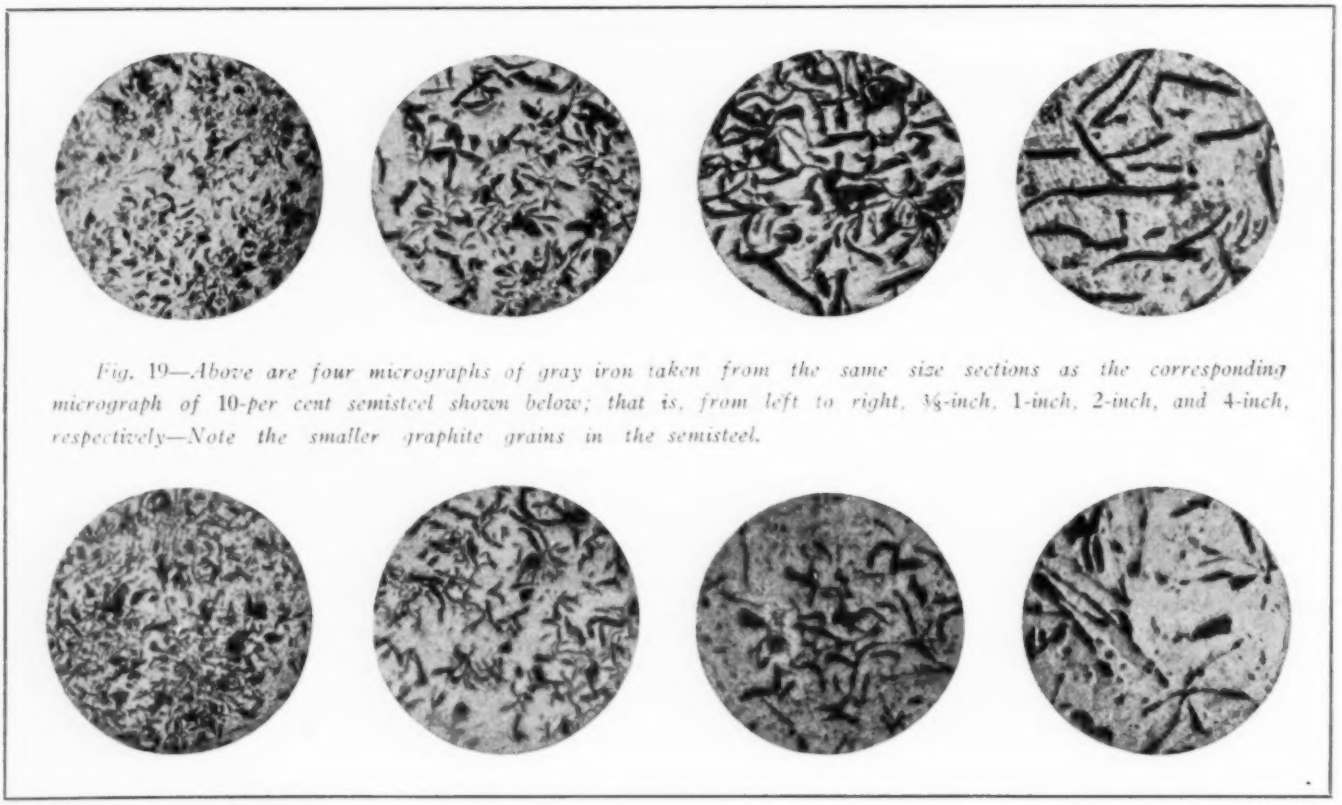


Fig. 19—Above are four micrographs of gray iron taken from the same size sections as the corresponding micrograph of 10-per cent semisteel shown below; that is, from left to right, ⅜-inch, 1-inch, 2-inch, and 4-inch, respectively—Note the smaller graphite grains in the semisteel.

Ferrite contains some carbon in solution—and possibly some in the colloidal state; because there is no such thing as absolute insolubility. In these statements the writer is not trying to draw any fine lines in terminology, especially as to states of division. This dispersed carbon, even though small in amount serves as a connector or *bridge* between flakes. Consider any two flakes, *A* larger and *B* smaller. At any moment each flake loses, on account of the kinetic motion of the carbon atoms, an amount of carbon directly proportional to its exposed surface. At the same time, due to interatomic attraction, it draws out of solution an amount of carbon proportional to its mass. It is at once evident that the big flake will take proportionally more carbon from the solution than the smaller, as it has less surface in proportion to its mass; that is, it gains more and loses less. The train of motion of dissolved carbon will move of an intermediate layer (in this case ferrite) which will permit motion of carbon. If metallurgists could find something which would obstruct carbon migration, the graphite growth problem would be solved.

Silicon Exerts Influence

The decomposition of pearlite cementite can occur in a similar manner. The graphite flake removes carbon from the adjoining ferrite. The presence of such elements as silicon probably exerts a powerful modifying influence on the carbon carrying powers of ferrite. The conditions promoting solution equilibrium lessen the carbon concentration near the cementitic particles. The kinetic *bombardment*, the metal remaining at constant temperature, of carbon atoms from cementite continues at the same rate while there is less reverse *bombardment*. Therefore, carbon atoms escaping the range of attraction (to cementite) are not replaced

matter of fact, they do. Polishing often drags a thin film of metal over the spots where the vertically oriented flakes lie. Figs. 1, 2, 3, 7 and 8 show the vertical flakes. Careful polishing and certain treatments will show the ends of the vertically placed flakes. That these rounded spots are graphite can be proved by showing their network structure and softness. While low magnifications may not serve to distinguish between graphite and various inclusions, moderately high magnifications (over 300 diameter) will bring out the difference.

Natural graphite, when found crystalline, generally occurs in the hexagonal system. Some writers claim that graphite flakes in iron occur in the hexagonal system. While the carbon of the graphite flakes is an aggregate of small particles, possibly of a definite crystal form, the total graphite flakes, in all cases which have come to the attention of the writer, can hardly be

assigned to any crystal system. These flakes are mixtures rather than definite crystal forms. The presence of the ferrite network and the conditions of formation would inhibit growth of perfect crystals.

Distribution Even Or In Whorls

Graphite flakes are not thin flat elongated plates. They are crooked rounded threads or pencils. The cross sections are round or square, or between the two. Graphite occurs in many seemingly characteristic arrangements. Little has been done to explain the causes of such arrangements. Graphite may occur in nearly straight flakes or the flakes may be decidedly hooked. It may occur evenly distributed or it may tend to form in bunches or whorls. Graphite flakes vary in size from those seen with difficulty under high magnifications—and probably smaller—to flakes over 0.01 inch long.

The per cent and condition of the graphite is one of the most important variables governing the physical properties of the metal. Notwithstanding this fact the data published concerning the properties of the metal do not often give enough experimental facts about the graphite in the specimens examined. The graphite variables are:

Per cent;
Size;
Shape;
Distribution.

The graphite flakes are sources of weakness. Excepting the effect of their ferrite network they act as so many cavities in the metal. Taking approximate figures the graphite occupies four times the volume per unit weight that the matrix does. Thus with 2.5 per cent graphitic carbon there is about 10 per cent cavities in the iron. This graphite is what causes the lower contraction of cast iron as compared to steel. The gravity of the graphite probably varies according to the conditions of formation. Gases may cause more graphite spaces per given carbon content. D. Wilkinson, THE FOUNDRY, Feb. 15, 1922, in an article entitled, Electric Furnace Strengthens Iron, shows that electric furnace melting may increase the specific gravity of the metal. It is quite likely that this effect is due in part to the formation of a more compact form of graphite. Such an effect would necessarily add strength to the metal. The use of steel in the mixture produces much more shrinkage. While this effect in semisteel is often due to an increase in combined carbon, it may be that the addition of steel promotes formation of more compact graphite. This is illustrated in Fig. 18. Lowering the amount of graphite also strengthens the metal, both by the direct effect of less weak flakes and by the indirect effect of raising the combined carbon.

Larger graphite flakes decrease the strength of the metal. A few isolated experiments here would indicate that increase in graphite size—other factors being equal—may decrease the tensile strength 15 per cent or over. The actual curvature of the graphite flakes probably has little effect on the strength of the metal because of the varied orientations of the flakes.

The distribution of graphite has considerable influence on the strength of the metal. Graphite may occur evenly distributed, or it may be bunched or in whorls. The latter conditions seem to weaken the metal somewhat.

In addition to its influences on the tensile and transverse properties, many large graphite flakes produce open grain and lowered resistance to shock. Most open grain is caused by large graphite flakes. The distribution of phosphorus also affects the grain of the metal, and the kind of cut taken in machining tends to give the appearance of either open or close grain to the metal.

The addition of steel scrap to the cupola charges produces an increase in strength seemingly out of proportion to its effect on the composition of the resulting metal. This phenomenon has not been fully explained.

Semisteel Not Identified Easily

In the trade a statement that a casting is a 25 per cent semisteel possesses little significance. In the first place analysis will not always give evidence as to whether steel has been added. While microscopic examination by an experienced operator might be a good basis for a shrewd guess, all semisteels cannot be distinguished from all gray irons by this method. Secondly, the physical properties may be no better than a good gray iron if the composition is wrong and the melting practice bad.

No general agreement has been reached among authorities as to the composition of semisteel. McLain* advocates high-carbon semisteel. Inasmuch as low carbon may indicate some oxidation high-carbon semisteel may give the best general results in small castings. In large, heavy castings the tendency toward more complete graphitization would often more than overbalance the effects of less oxidation. The writer has seen cupola semisteels to which from 10 to 40 per cent of steel scrap was added, which ranged from 2.44 to 3.65 per cent in total carbon, depending on the amount of steel, the coke, the cupola operation, and the composition of the pig iron.

A fairly good cast iron will have about 22,000 pounds per square inch tensile strength. A normal 10 per cent semisteel will run about 30,000 pounds per square inch, and the better grades of semisteel have a tensile strength over 35,000 pounds per square inch. These properties may be considerably decreased or increased by the methods of melting and of casting the test bar. However, it is safe to say that an iron, cast in a 1⅛-inch diameter bar in a sand mold and cooled in the mold, which has a tensile strength of over 30,000 pounds per square inch is a semisteel, unless cold-blast pig iron has been a component of the mixture; and this is practically never used for cast iron in America.

Semisteel generally melts hotter than regular iron. Semisteel is in the melting zone longer (while the steel scrap absorbs carbon and lowers its melting point) and gets more superheat. Some foundries use more coke when melting semisteel. The combined carbon in semisteel test bars is not always in the form of coarse pearlite. The higher transition forms, from the austenitic to the pearlitic state, are much stronger than pearlite. The foundryman, the designer and the buyer should remember that the test bar does not always represent the casting. Forty-five thousand pounds per square inch tensile strength in the test bar may give only about two-thirds that strength in a heavy casting.

For heavy castings the following will give the best results for strength:

As low total carbon as is consistent with a hot, fluid iron, free from oxidation.

A section size as small as is consistent with the function of the casting.

Relatively low silicon to prevent formation of a hypo-eutectoid matrix with much free ferrite.

Fairly high manganese, somewhat over 6 times the sulphur content.

A fairly high sulphur content—from 0.10 to 0.12 per cent.

A fairly low phosphorus content.

Combined carbon should not exceed 1.0 per cent. In ordinary practice such an iron might be a little lower in combined carbon to give greater machineability.

Graphite Complex

Graphite in cast iron is a complex structure. It contains graphitic carbon, ferrite, gases and sulphides. Its gravity may vary with the conditions of formation. Graphitization starts at solidification and probably continues to somewhat below the austenite—pearlite transformation range. Adoption of the kinetic viewpoint will simplify consideration of the mechanism of graphitization. In future research more attention should be given the states of graphite in the metal. Correlation of microscopic, physical and analytical data will furnish a firm foundation for practical improvement in gray iron and semisteel.

*Communication published in THE FOUNDRY, Feb. 1, 1922.

Cast-Iron Pots Made In China

Practically Unchanged for Centuries the Oriental Foundryman of Today Makes Molds for Castings That Would Be Considered Difficult with the Best of Rigging and Under the Most Modern Conditions

BY W. E. JEWELL

BASING a comparison of occidental and oriental foundry methods on mass production or scientific control, would lead one to the conclusion that in those far eastern countries the casting industry still is in its infancy. Historical evidence would seem to indicate that like many other forms of industry, founding of metals was practiced in China probably before any other place on earth, a factor which completely dispels the infancy theory and a closer study of the subject will convince any person that the comparison is not so overwhelmingly in favor of modern occidental methods as might at first appear. For example, consider the feature known as overhead. It is recognized as a factor, a kind of a necessary evil connected with modern manufacturing methods. The owner of the business or the manager devotes many of his waking hours to devising some means for reducing this form of burden. He tries to increase production, installs labor saving machinery, faster working equipment, anything irrespective of the cost, that will distribute this expensive overhead and show a lower proportionate rate in the total cost of manufacture of his various products.

FIG. 1—THE BLAST PIPE IS SET OPPOSITE AND SOME DISTANCE BACK FROM THE TUYERE OPENING—WHEN SUFFICIENT IRON HAS BEEN MELTED, THE CUPOLA IS TILTED FORWARD AFTER THE MANNER OF THE FAMILIAR BESSEMER CONVERTER

The Korean or the Chinaman is not concerned with problems of that character. His business is conducted in a manner that simply eliminates *all* overhead. His overhead may be said to be the clear skies above in more ways than one. Practically 90 per cent of all foundry operations are carried on out of doors. When it rains part of the foundry crew works under a kind of shed, open at the front and both ends while the remainder go fishing. Cash is paid when a sale is made, thus automatically eliminating all overhead involved in keeping sets of books and records. Workmen's compensation insurance is unknown. No salaries, no clerks, no bosses, no income tax, in fact no "nothin'" but just 100 per cent foundry.

Several interesting visits were paid to foundries in Shingishu, Korea and the following description of some of the curious foundry methods and devices—curious to western eyes—seen there, apply equally to foundries in other parts of Korea, Manchuria and the interior provinces of China.

The cupola usually is about 5 feet high, made in two sections, a bowl provided with trunnions forming the bottom and a plain cylinder forming the top section. As a general rule, the upper section is made of cast iron,

The material and photographs for this article was supplied by W. E. Jewell, president of the Jewell Steel and Malleable Co., San Francisco, who recently has returned from a tour of the Far East.

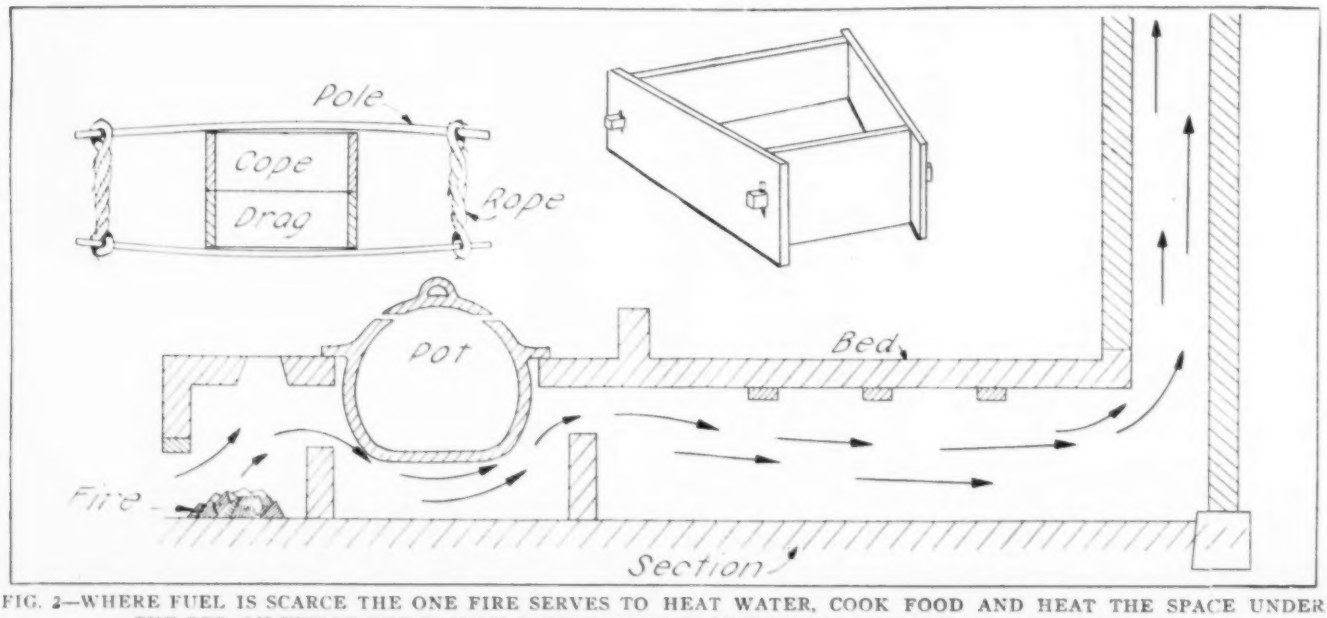


FIG. 2—WHERE FUEL IS SCARCE THE ONE FIRE SERVES TO HEAT WATER, COOK FOOD AND HEAT THE SPACE UNDER THE BED ON WHICH THE FAMILY SLEEPS—ABOVE—PRIMITIVE FLASK AND CLAMPING DEVICE

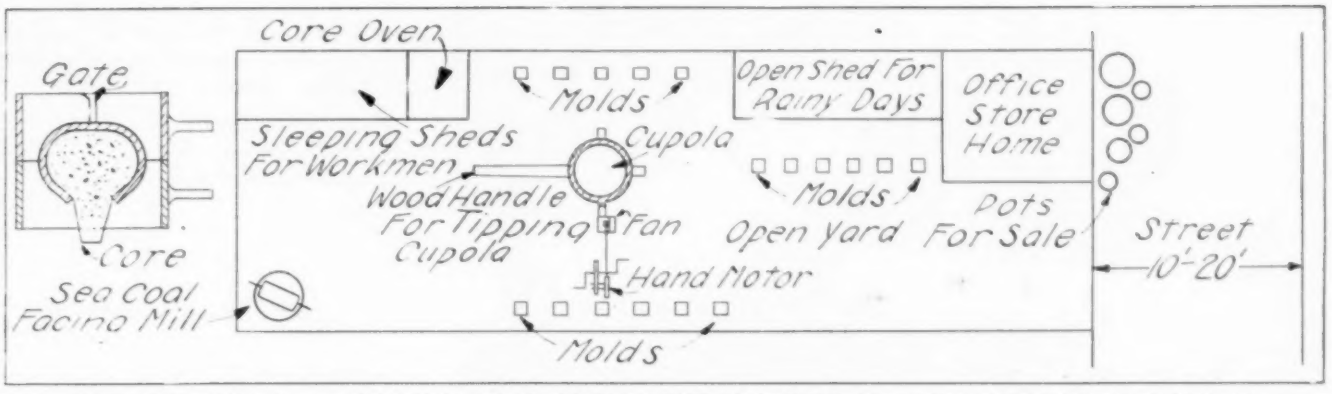


FIG. 3—LEFT, METHOD OF MOLDING A POT—RIGHT, GENERAL LAYOUT OF A TYPICAL ORIENTAL FOUNDRY

but sometimes it is made of sheet iron and in other instances it is made of brick bound together with rice straw ropes. As a melting medium it is the essence of simplicity, no swinging drop doors, no elevator, no charging cars, no blast gage, no windbox to fill with slag, no scale, no tapping bars, just simply a tilting cylinder filled with fuel and iron and the quality and fluidity of the metal turned out is surprising. The motor for the fan is a compound gear mounted on a small scaffold and driven by two double crank arms manned by four coolies. On account of tipping the cupola, the blast pipe from the fan is not attached to the tuyere opening in the shell. It is arranged to come in line with the opening, but naturally a considerable volume of air escapes in the jump between the two openings. With a good, tight joint, two men could drive the fan fast enough to deliver a sufficient quantity of air, but apparently it is considered cheaper to pay the wages of two extra men for an hour or two, every other day, than it is to provide a flexible connection. The fan is left on until about two hand ladles of metal are melted. Then the cupola is tipped forward and drained of both slag and iron through the open breast which never is closed during the progress of the heat.

Many of the flasks are made of wood, with the corners mortised together and tightened with wooden wedges. Iron or steel mills are considered too precious to be wasted on the construction of foundry flasks. The greater number of flasks are made of iron. Instead of the usual clamps employed at casting time, two poles are extended across each flask, one on the bottom and one on the top. The ends are bound together with rice straw ropes, twisted in place to produce a tension on the ends of the poles and thus binding the two parts

FIG. 5—A SEMI-PERMANENT MOLD USED IN A FOUNDRY IN SHINGASHU, KOREA, FOR MAKING COOKING POTS

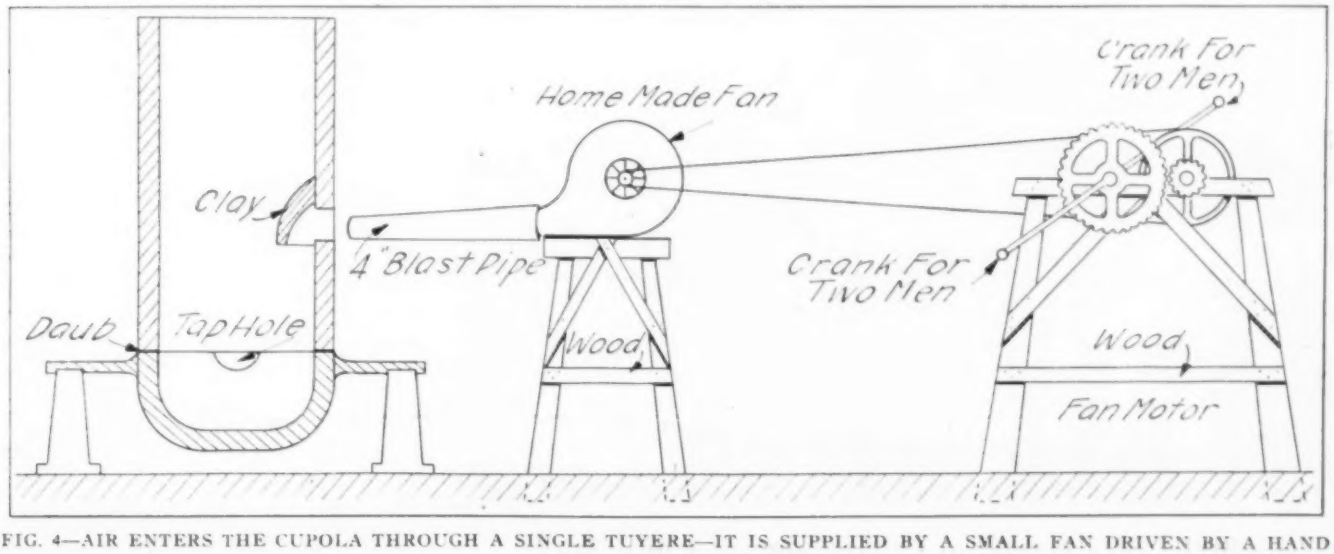


FIG. 4—AIR ENTERS THE CUPOLA THROUGH A SINGLE TUYERE—IT IS SUPPLIED BY A SMALL FAN DRIVEN BY A HAND OPERATED "MOTOR"

FIG. 6—A PRIMITIVE BUT EFFICIENT RIG FOR GRINDING SEA COAL FACING

of the flask together, as shown in Fig. 2.

The foundry, generally, is located on Main street. The owner lives in a shed-like structure in front, where he displays his wares, pots, grates, stoves, spoons, etc., in the open street. The foundry and lodging for the men are in the rear. Molding sand is brought to the foundry on double trays suspended from a pole over the shoulders of a coolie. Pig iron and scrap are transported miles in the same manner, although occasionally oxcarts are employed. Common labor is paid at the rate of 25 to 50 cents a day. Skilled labor receives a little more. These little shops melt from 1 to 2 tons every second day. Of course in many of the great, open-port towns, modern equipment has been installed in large foundries, but an immense quantity of castings are made according to the foregoing description. Usually the castings are good, smooth and soft, but there are exceptions, even as in our own country where some foundries turn out an inferior product.

Pots for household use constitute an important part of the foundry output. They are made in many sizes, but all conform to one of two general designs; those that are contracted at the neck and provided with a cover, and others, made after the general style of the ordinary cast-iron, wash boiler kettle. These castings sell for from 5 to 8 cents a pound, retail.

With an average thickness of 1-8 inch and with a set of lugs cast on the outside for supporting the pot in the brickwork, these castings would be considered difficult by the average American foundryman and it certainly

FIG. 8—LUMBER STILL IS SAWED BY HAND WITHOUT EVEN THE CONVENIENCE OF A SAW PIT—MAKING FLASK LUMBER

FIG. 7—ALL KINDS OF MATERIALS, MOLDING SAND, PIG IRON, WATER, CASTINGS, ETC., ARE CARRIED IN TRAYS SUSPENDED FROM THE COOLIES' SHOULDERS

is surprising to note how easily, cheaply and well the work is done in these little hole-in-the-wall foundries. The boiling pots, those contracted at the top, are made mouth down as in ordinary American practice. However, they differ in that while the outside is made in green sand, the interior is formed with a dry sand core. To provide for the contraction of the casting the core is filled with coke, grass, roots and other waste material. These castings range from 20 to 30 inches diameter, 12 to 16 inches deep and with from 1-8 to 3-16-inch thickness of metal. Arbors are employed to reinforce the cores and the outside surface which comes in contact with the iron, is black-washed. An exceptionally long print locates the core accurately and when packed in tightly, holds the core firmly in place while the mold is filled with iron. The casting is poured through a single gate on the top and since the metal sets almost as fast

as it is poured in such a thin section, there is no danger of the core *floating*. The casting is shaken out immediately after it is poured and the stump of the gate rubbed off with a crowbar or a stone.

Pot lids are made in what might be termed semi-permanent molds. A dry sand mold made in an iron flask is employed. The lids are only 1-8-inch thick and since they are shaken out immediately after they are poured, the sand in the mold is not burned to any extent. This part of the work is handled rapidly and it is not uncommon to pour two or three lids in the one mold from a single furnace tap. The furnace is tapped at 15-minute intervals and produces not more than 5 small hand ladles of iron each time.

The second class of pots, in which the circumference is greatest at the mouth, is used for cooking the food. These range in diameter from 14 to 30 inches depending, as the Chinaman says, on the number of mouths to fill. The chow, consisting of various vegetables, rice, meat, etc., all is cooked together in this iron pot, bricked in to a foundation which furnishes insulation and conserves the heat from the fuel. In many districts, grass, roots and small twigs are the only fuel available. The pot is made in a semi-permanent mold prepared in a manner similar to that described for the lid. Several interesting features in connection with the construction and application of one of these molds are shown in Figs. 2 and 3. The cope flask is an iron frame conforming to the shape of the pot and made up of several longitudinal and vertical bands spaced widely apart. The spaces between the bands are filled with a species of clay afterward baked hard. The surface is vented all over and care is observed to see that these vents are kept open all the time the mold is in use. Handles are provided on each side for lifting the cope off and on and after the mold is closed ropes are twisted around the handles and around a corresponding projection on the base plate to bind the two parts of the mold together.

Occasionally the first casting poured in the mold is cold shut, or defective around the lower edge. The casting is not scrapped. The Oriental wastes nothing, throws away nothing. He sells a pot of that kind at a slightly reduced price. After the mold is warmed, a cold shut, a crack, or defect of any kind rarely occurs. The mold is poured through a single gate on the top. The usual practice is to employ a round gate ¾-inch in diameter, but occasionally a flat or wedge gate is used. The mold will make a considerable number of castings without retouching, but a new gate must be rammed in green sand for each one. A round hole is provided in the material forming the top of the permanent mold for this purpose.

Keeping Down Maintenance Expense

BY D. J. PERDUE

NECESSARY equipment in a foundry of 2500 to 3000 tons per month capacity will cost many thousands of dollars and if not properly taken care of the maintenance cost per year will run into large figures. Maintenance and repair work is one item in foundries that is usually classed as nonproductive labor.

The maintenance superintendent should have an accurate cost system for his department that will show at the end of each month just what it has cost to operate each individual machine, and every foreman should be furnished with a report showing this cost.

The waste and loss due to carelessness of repairmen are enormous and with a little effort on their part quite a saving can be made. Faulty lubrication costs the average foundry many dollars a year, and this seems to be one items neglected. Nothing is done to remedy the cause. The burned out bearings are replaced only to burn out shortly again.

Oil, grease, paint and other liquids are usually bought in barrels or some other kind of containers. These are charged to the purchaser and a credit is given when the containers are returned in good condition, or if not returnable they usually can be sold elsewhere. Cable, wire and hose is sold on wooden reels which can be returned for credit. Boxes can be sold to packing and storage houses, and cement sacks can be returned to dealers for credit.

In one foundry alone, where many large grinding wheels were used, the lead bushings were saved for one month and sold for $38.90. These results were so gratifying that the practice was established as regular routine. All grinding is done on a piecework basis and now the workmen turn in a lead center to the foreman before they can get a requisition for new wheels.

Another instance is a repair on a large piece of machinery such as a gantry crane where many bolts and rivets are used; the foreman makes out a storeroom requisition for the material for this job, charging it to the account number for this machine and in almost every case there is some material remaining unused. What becomes of this material? It is invariably thrown in a box or keg to be used on the next job but when the next job is started this material is forgotten and in time the shop gradually gets littered up with a few bolts here, some rivets over there, a piece of cable hanging up on a nail, etc. This material should be taken back to the storeroom and a credit slip made out against the account number for the job, thus charging only the material used.

If the foremen over the pipefitters, electricians, repairmen, millwrights, carpenters and yard labor can be made to see the importance of minimizing waste they will endeavor to accomplish all savings. Giving each foreman a report every month showing his department expenditures will help see where expenses could have been cut.

In keeping a system to give data of maintenance costs the accounts should be numbered so that they can be identified easily. Thus each department should be assigned a block of 100 numbers, thus the open-hearth department might have all accounts in the six hundreds and the foundry and core departments all accounts in the seven hundreds, etc. Identification might be made still simpler by adding an *M* to all material account numbers. Thus labor in repairs to the open-hearth furnace would be under account number 602 and materials used for the same purpose would be under account number 602M, and so on for every account.

When such a system is put in operation it is essential to secure the co-operation of all departments on which it is dependent, such as the auditing, bookkeeping, stores and maintenance, to insure its successful functioning.

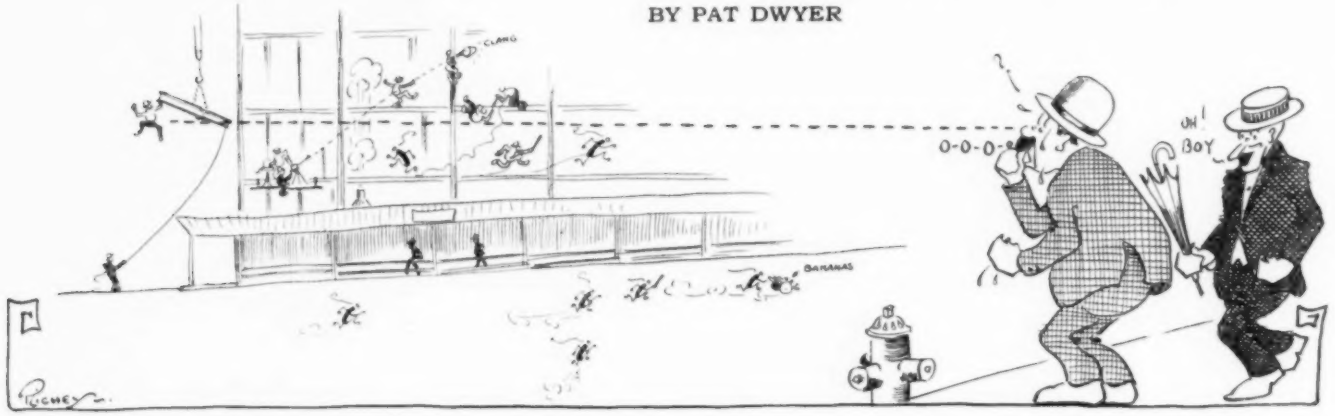
A list of charge accounts should be furnished to the foreman of each department with instructions to be careful to put the correct account numbers on all storeroom requisitions for material and also on the workmen's time cards.

A strict application of this system will enable the maintenance costs on each machine to be determined and this can be used as a guide in deciding whether to scrap a machine and purchase a new unit.

W. J. Smith has been appointed special sales representative for Ohio and Michigan for the Hill & Griffith Co., Cincinnati, O.

Bill Discovers Why Castings Warp

BY PAT DWYER

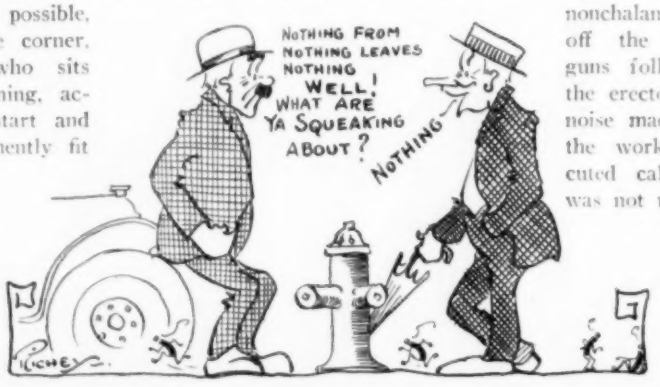


JUST at the moment, which of course is only the conventional method of saying that I never knew it, I cannot recall the name of the eminent person responsible for the saying: "Variety is the spice of life." Anyway, what difference does it make, at this late date, either to us or the inventor? We are familiar with the statement and accept it as a matter of course. The inventor, or originator, long since has ceased to maintain an active interest in wordly affairs—Note here, loud and prolonged objection from Sir Conan—and although probably he has experienced the truth of his famous remark to a greater degree since he departed for the other shore, up to the present he has not favored us with his views.

Many years ago I met, and in fact became quite interested, in one of his lineal descendants, whose peculiar hobby it is never to eat in the same restaurant more than once in any given calendar year. I have trailed along dutifully, on several occasions, but so far I have failed to note any striking difference between one eating place and another. It is possible I have not the true artistic temperament which requires, or thinks it requires, constant change and excitement, either real or fancied. In fact I am so prosaic that I prefer to sit in the same chair, at the same table, night and morning and I like to sit in one definite restaurant at noon and, if possible, at the same table in the same corner, day after day. The lady who sits opposite to me night and morning, accepts the arrangement at the start and close of the day, as being eminently fit and proper, but when I tell her that I prefer a chair at a certain table at one particular restaurant every noon she is pleased to construe and describe my action as a sign of approaching senility. She is quite a variety artist in a culinary way and is competent—and willing—to pass expert opinion on practically any mixture of that character placed before her. Further, in the course of a long acquaintance, I never yet have seen an article of food, provided it was still in the eligible class, which she has refused to eat—and eat successfully. Many people eat certain food which later causes them feelings of the most deep and poignant regret; but, to use a popular descriptive phrase, she will eat anything that does not talk back to her.

For some considerable time I have been taking my modest noonday repast at a place located across the street from a huge steel office building in course of erection and from constant association have come to feel a mild personal interest in the progress of the work.

A wrecking crew armed with sledge hammers and crow bars tore down and dismantled the buildings formerly occupying the site of the proposed structure. This part of the work proceeded with the usual hurry and was marked by some slight excitement and a few fatal accidents to workmen buried in the falling walls. Then the huge steam shovels burrowed for weeks in an ever-deepening excavation that made me wonder whether the proposed building was to be erected under or above ground. Owing to the peculiar geological formation, it was found necessary to drive piles over a considerable portion of the area after the excavating was finished and for several weeks the pile driver rams rose and fell forcing the long sticks into the ground. Then a flock of carpenters swarmed over the place, knocking the forms together and for several weeks thereafter the concrete mixers poured a steady stream of liquid stone into those forms embracing and submerging the myriads of twisted steel bars cunningly arranged for reinforcement.

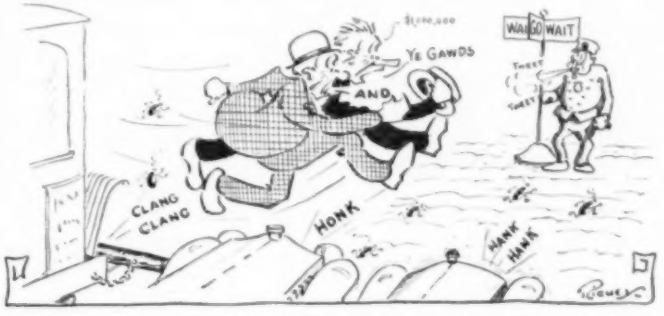


MUCH ADO ABOUT NOTHING

After the concrete had set, a lofty steel derrick swung girders and beams and columns into place quietly, efficiently and almost as swiftly as a boy putting a mechanical toy together. A comparatively small number of spectators seemed interested in the construction of the building up to the fifth or sixth story, but from then on, continuing up to the fourteenth floor, it was not uncommon to find dozens of people standing on the sidewalk across the street watching the big beams slowly sailing up into the air and dropping into place according to the whistled signals of a man perched on a coign of vantage where he could watch everything that went on. Two men were waiting, one at each end and as the beam settled into place, each one located his end definitely by inserting the sharp pointed handle of his spanner through a hole in a previously erected member and through a corresponding hole in the end of the beam. He then inserted a bolt or two, ran a nut down with the spanner and then walked out nonchalantly on the beam and threw off the slings. Men with rivetting guns followed closely on the heels of the erectors. With the exception of the noise made by the signal man's whistle, the work of the erectors was prosecuted calmly, swiftly and silently and was not unlike some of the scenes sometimes thrown on the screen, but the constant roar of the riveting guns left no doubt that the operation was real, that something tangible was being done and done in a highly creditable manner, by a gang of real he-men with

hair on their chests and horny palms.

The other day, comfortably filled, not over loaded you know, but with sufficient fuel aboard to carry me through a strenuous afternoon and last me until I reach the home port about 6 p. m. I emerged from my favorite eating place and strolled over to the curb. Here, in defiance of all rules and regulations to the contrary, made and provided for the purpose in the face of a public that paid no attention, I toyed languidly with a tooth pick while casting an appraising and appreciative eye over the progress of the new building since the preceding day at noon. On this occasion I was treated, if treated is the proper word, to a new thrill. After one of the workmen had adjusted the slings on a beam, he stepped on the center and was carried aloft to the top of the building. I can't say that my heart stopped, or that I did not take a breath until I saw him step off the beam; but I had that peculiar feeling I experienced the first time, and for that matter each time, I have seen Strong Tooth slide from the top of the tent pole to the ground, suspended from a rope by a piece of leather grasped between the teeth.



RISKY JOBS ARE NOT CONFINED TO TALL BUILDINGS

Quite probably you have shared this experience on many a memorable occasion and therefore there is no need of reconstructing the scene for your benefit. The sudden hush as the artist prepares to swing off into space, the long crescendo roll of the snare drum culminating in one bump on the bass drum as the hero or heroine, as the case may be, lands in the net or on the ground. Of course, in this instance the direction of flight was reversed and the performer flew aloft instead of gliding toward the earth, but the effect on the spectators at least judging by my own feelings, was practically the same.

While gazing aloft, I had been conscious for some time of a person standing beside me, but as the location was a busy down town street, where thousands constantly pass to and fro, I paid no particular attention to my companion until after I had seen the man safely land on top of the building. Then I brought my gaze back to earth, preparatory to starting on the return journey to the scene of my daily toil and was agreeably surprised to find that the person on my right was indeed no other than my old friend Bill, himself in person.

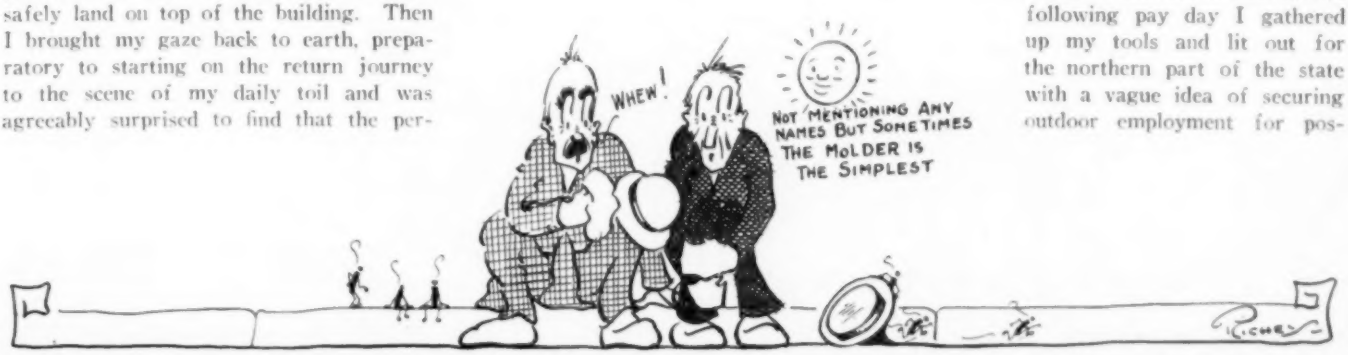
"Pon my word," said he "For a man who has played in the big league as long as you have and seen the high buildings in nearly all the principal cities in the country, you can give the best imitation of a hill-billy in town for the first time, of any person I know. It is a source of constant wonder to me how you have remained so long immune from the attentions of those nimble fingered gents who improve every shining minute by lifting watches and other forms of valuables from innocents like you who stand, mouth agape, looking up at the tall buildings across the street."

I told him he was wrong, as usual, that as a detective and reader of character he would make a fine hod carrier. I directed his attention to the fact that I carried neither watch or jewelry and therefore I was perfectly safe no matter where I parked my feet, and irrespective of who stood front, back, or on either side of me. Nothing from nothing leaves nothing and any unfortunate and misguided pickpocket who selected me for a contributor would get stung and that was all he would get unless I saw him in time and then probably he would get a poke in the jaw.

"Fine words," said Bill. "I am glad to see that a little of the old leaven is left and that you are not quite such a hopeless case as I at first imagined. However, prithee tell me gentle sir, if you are not bound by a vow to remain silent on the subject, tell me what you are doing here at the hour of high noon, when you should be up and doing about the master's business?"

We walked down the street in the general direction of the old nest and as we went along I outlined for his benefit what I already have set down. In continuation I admitted to Bill that if any person were to offer me a Million Dollars—it looks bigger when spelled out—I would not accept a job that involved skipping around on little narrow beams half a mile in the air. Even while making the statement I realized that there was not the remotest chance of any plutocrat coming forward with the necessary amount and the half mile may have been a slight exaggeration. Nevertheless, I made the statement and was prepared to defend it to the best of my ability should Bill see fit to shoot it full of large sized question marks. Bill's mind went off at a tangent, a not infrequent occurrence, and I was relieved of the necessity of presenting any defense. "You would become accustomed to it in a short time," said he, "and think no more of walking across the edge of a girder on the tenth story than you now would of walking a straight line on the floor. The sense of personal danger would not be present to affect your actions. I had a spell at it one time many years ago and while I accepted the job with all kinds of misgivings and forebodings, I gave it up after nearly a year with something like regret. I blew into Pittsburgh in the early summer and landed a job at the Mesta. The weather kept getting hotter and hotter and through constant sweating I kept getting thinner and thinner until at last I fully believed that in about another month there wouldn't be enough of me left to justify funeral expenses. In imagination I saw the undertaker come pussy footing into the boarding house, lay his tape over me and then return in the afternoon with something neat and tidy under his arm, in the shape of a little narrow snap flask provided with near-silver handles.

"I decided I had better draw my back time while I still was in a condition to ask for it and on the following pay day I gathered up my tools and lit out for the northern part of the state with a vague idea of securing outdoor employment for pos-



SIMPLICITY IS A VIRTUE AND HAS A LEGITIMATE PLACE, BUT WHO WANTS TO BE CALLED SIMPLE?

sibly a year, or until I had once more rounded into shape. I landed a job with a structural iron firm and was sent out on the road with a bridge building gang, first as water boy, then successively as my muscles hardened and the flesh began to cover my bones, as heater, bucker-up, and before the winter was over, I was handling a gun as carelessly on the top stringers of the bridge as any bucko on the job. With the coming of summer, a combination of circumstances served to send me back once more into the foundry. The job was finished and our next assignment was down in the southern part of Tennessee. I was feeling as fit as a fiddle and did not fancy the idea of broiling like a herring on a griddle. The poetry, my boy, just goes to show how frisky I was feeling about that time. So having satisfied myself that the class of work handled in one of the foundries in the town was of a character worthy of my best efforts, I quit the bridge building gang and, as they say in the higher circles of industrial life, accepted a position in the foundry.

"The gaffer kept a friendly eye on me for a week or so and then, apparently satisfied that I knew my way around he indicated what job he wished me to work on and left me to my own devices in-so-far as selecting flasks, setting gates and risers and other details of the character. The work was familiar, I was quite satisfied with myself, thank you, and then I lost a casting under such simple circumstances that it knocked all the conceit out of me for many a long day. However, the episode taught me a lesson that has stood me in good stead on many a subsequent occasion. When I look back now at that shop and the kindly and competent old man who presided over it, I am inclined to thank my lucky stars that the apparent mischance happened when and where it did.

"One morning the foreman pointed to a cylindrical pattern 4 feet long and 1 foot in diameter and told me to make a casting 8 feet long. He suggested that I draw the pattern 1 foot extra, or 9 feet over all, the extra foot of metal to serve as a sink head. He also said he wanted a perfectly clean casting and I had better make it on end, in dry sand. The thing looked so absurdly simple that I was surprised he had not given it to one of the apprentices and felt slightly peeved at being delegated to make what I considered a plain round plug. I decided to run it at the bottom and, with a natural desire to conserve sand and muscular effort, I selected a sufficient number of round iron flasks each 1 foot deep and 20 inches in diameter. I felt a little doubtful about the gate breaking through, but by crowding the pattern close to one side of the flask and the gate close against the opposite side I considered that the procedure was reasonably safe. I fully realized the possibility of ramming the pattern away from a straight line on account of drawing it up every foot of distance and observed all the necessary precautions to prevent an accident of that kind. I leveled the first drag, bedded the pattern in and tested it both ways for accuracy with a level before ramming any sand around it. Then I set a flat draw-gate tangent near the bottom and rammed two rings full of sand around the pattern. I made a parting at this point to facilitate blacking the mold later, then drew the pattern about 12 inches, set on additional rings and repeated the performance to the top. I made a second parting about 3 feet from the top and paid particular attention each time I drew the pattern to see that the upper surface was perfectly level. Apparently everything went along all right until the casting was shaken out and then I was invited down to the cleaning room to see a perfectly clean casting, but unfortunately with a camber of 1½ inches in the entire length. I experienced a distinct shock and since I was so positive that I had made a perfectly straight mold I was at a loss to account for the hump back casting.

The old man must have had his suspicion, for he immediately asked me to show him the flasks in which I had made the thing. Then he pointed out to me that on account of the manner in which I had crowded the pattern close to one side of the flask, the casting had cooled on that side first and pulled itself out of shape. That was a feature I had not taken into consideration, but you can bet when I made the next one it was in the exact center of the flask. I also did away with the long down runner and the gate at the bottom. The old man had a covering core made, provided with about a dozen small pop gates. I set a ring core on top of this to form a runner basin and poured the casting through the top and that casting was as clean, straight and true as a gun barrel.

"No sir" said Bill in conclusion; "These simple little silly jobs are not always as simple as they look. Sometimes the molder is the simplest factor in the equation."

Organize Fuel Company

The Quigley Fuel Systems, Inc. has been organized with general offices at 26 Cortland street, New York. This embraces the business which has been conducted as the Quigley Fuel Systems department of the Hardinge Co. Inc. and which up to a few months ago had been the pulverized fuel department of the Quigley Furnace Specialties Co. William H. Baker is president of Quigley Fuel Systems, Inc. and W. O. Renkin is managing engineer. L. W. Marso represents the company in the Pittsburgh district. The new company is entirely independent of the Hardinge Co., although Mr. Baker continues as vice president and consulting engineer for the Hardinge Co. The company is just completing a large installation of powdered coal in the steel works of Societe Anonyme Ougree-Marihaye at Liege, Belgium.

British Furnace to Be Built in America

Arrangements have been made by the Monometer Mfg. Co., Ltd., Savoy House, Strand London, W. C. 2, England, for the construction of its melting reverberatory, hardening, annealing and other furnaces for the United States, Canada and South America, by the Monarch Engineering & Mfg. Co., Baltimore, Md. This will add considerably to the already extensive lines of furnaces built by the Monarch company. Monometer furnaces are already being manufactured by another company in France, and arrangements are now being made to have them built in Berlin for German, Russian and Central European trade.

Book Review

The International Molder's Union of North America; by Frank T. Stockton Ph. D.; professor of economics University of South Dakota; paper; 218 pages 5½ x 9 inches; published by the Johns Hopkins Press, Baltimore and furnished by THE FOUNDRY for $1.50 net.

This book constitutes volume 39 of the series of Johns Hopkins University studies in historical and political science under the direction of the departments of history, political economy and political science. It is a study of a single representative trades union with respect to all its policies and problems. The subject is covered in 14 chapters with numerous foot notes and references on almost every page. The scope of the work may be gathered from the chapter headings: Rise of the early local unions, founding of the international union, government, jurisdiction, membership, finance, mutual insurance, control of strikes, national collective bargaining, standard rate, hours of labor, apprentices and helpers, molding machinery, the closed shop, the label and the boycott.

Pilling & Co. will move their New York office from 71 Broadway to 2 Rector street, May 21.

Correcting Flaws in Metal Mixtures

Problems of the Gray Iron, Malleable and Steel Foundry Discussed

By H. E. Diller

Steel Inserts Cast into Gray Iron

Question—We are making gray-iron castings in which steel bars are cast, and find blow holes where the molten iron strikes the steel. Is there any way to prevent this?

Answer—You could avoid having your iron kick or blow when it strikes the steel inserts by cleaning and drying the steel and then coating it with a thin coat of shellac. The shellac should be dried and allowed to harden in the air before the steel is used in the mold. Another procedure would be to wash the surface of the steel with a thin mixture of litharge in dilute water glass. The same precautions in regard to drying would have to be followed in this case as when using shellac.

Melting Iron Borings

Question—Can cast-iron borings be used in large proportions in the cupola?

Answer—We know of no foundry where cast iron borings are used in the cupola with any great commercial success unless they are first briquetted. A few foundries melt borings by packing them in containers, sometimes with a little coke dust, and putting the containers toward the center of the charge. Containers are usually cans or sheet iron pipe bent over or covered at the ends. In a few instances wooden boxes have been used.

Iron Not Satisfactory for Permanent Mold

Question—We are making castings in an iron form which makes the iron hard, also it is difficult to run metal over an iron chill and further these iron molds become very hot in a short time. Do you know of any heat resisting material from which we could make a mold that we could use continually as we use our iron molds, one that would neither warp out of shape, crumble, or break.

Answer—Your inquiry is a difficult one to answer. Many foundrymen for years have been trying to secure a permanent mold other than iron for iron castings but so far have not succeeded. Cast iron molds are washed on the surface with graphite occasionally to extend the life and an interval of time is left between each two casts so that the mold does not become overheated. Under certain conditions and worked this way the cast iron mold has proved satisfactory for certain lines of castings. To prevent the iron from becoming hard it is taken out of the mold as soon as possible after it sets. In this way a soft close grained metal is secured.

Pin Holes In Castings

Question.—We would like to know the cause and prevention of pin holes in steel castings immediately under cast-iron, wrought-iron or steel chills.

Answer.—Pin holes may be caused in steel castings at sections against chills by moisture on the surface of the chill or by slightly oxidized steel. To obviate the former source the chill should be thoroughly dried and heated before the casting is poured. Should a green-sand mold be used the chill should not be left in the mold long before casting. Care should also be taken to have the steel deoxidized.

Internal Chill In Casting

Question—We are sending you a piece of gray-iron casting and wish to call your attention to the white spots in it, which look like chilled iron. Could you tell us the cause of these sections? Several theories have been advanced to us to account for the condition.

Answer—The phenomenon shown by the sample of gray iron which you sent us has been frequently noted by foundrymen but no explanation has been generally accepted for this condition. In one sample which the writer analyzed, it was found that the amount of total carbon in the white iron differed considerably from that in the gray portion, but otherwise the composition of the two metals were almost identical, except, of course, that the carbon in the white iron was mostly in the combined state while that in the gray iron existed almost entirely as graphite. We would like to hear some of the theories which have been advanced to you for this condition as we have never heard any theory which seemed plausible.

Causes of Rough Surfaces on Castings

Question—Would the composition of the metal cause a rough surface on gray iron castings?

Answer—Unless the composition was far from normal, there would be no effect on the surface of the castings. If the sulphur was too high, there might be a slightly roughening tendency and pin holes. The pin hole effect might also be caused by oxidized metal. If the silicon was low and the iron extremely hot, it might have a tendency to burn into the sand. However, if the sand is of a low fusing point, especially if the casting is heavy, the iron would have a tendency to fuse with the sand and cause a rough surface.

Burning Out Grate Bars

Question—What degree of heat will it take to burn out a grate bar in a stove?

Answer—We can give no definite figures for your question as to what degree of heat it will take to burn out a grate bar in a stove. The grate bar is burned out due to oxidation which requires time. Therefore, the elements of time and heat both enter into the problem and these are modified somewhat by the ability of iron of different compositions to resist oxidation. We can only say that the higher the temperature, the quicker the grate bar will burn out. If the bar is kept at a bright red heat, it will not last long.

Pickling Rusts Castings

Question—We pickle a large percentage of our gray-iron castings and receive complaints from our customers that the castings are rusty. Can you advise how to treat the castings to prevent the pickling solution from rusting them?

Answer—After the castings are taken from the pickling solution they should be dipped in a diluted solution of caustic which is near the boiling point, then into a bath of hot water. When taken out of the second bath the water will dry from the castings and leave a clean surface. However, should there be any crevices in the castings which hold the liquid the castings should be heated somewhat as soon as they are taken from the solution to thoroughly dry them.

Cast Nickel-Chromium Alloys

Metals Are Melted in Induction, Arc and Crucible Type Electric Furnaces—Purity Found To Be Essential—Iron Added To One of the Alloys—Occluded Gases a Menace in Melting

BY E. F. LAKE

METALLURGISTS and foundrymen generally are not familiar with the melting and casting of nickel-chromium alloys. These alloys are made in three grades by the Hoskins Mfg. Co., Detroit. One grade contains 80 per cent nickel and 20 per cent chromium, with only traces of iron; a second grade is composed of 85 per cent nickel and 15 per cent chromium, while a third grade carries 64 per cent nickel, 11 per cent chromium and 25 per cent iron.

These alloys can be cast into intricate shapes, forged, hot or cold rolled, or welded to themselves or other metals. Wire is drawn down to as fine as 0.0015-inch diameter and ribbons are cold rolled as small as 0.002 x 0.0155-inch. Thus, the metal can be used for castings, pyrometer couples or resistance ribbons.

The foundry of the Hoskins company produces all kinds of castings and also casts the ingots for the rolling mill. To get good castings it is essential that the mixing and melting of the alloy be correct. Impurities of all kinds must be kept down to traces only, or they will lower the resistance of the alloy to electricity, heat, oxidation and corrosion, and these are the essential reasons for its production. All elements are classed as impurities in the two best grades except nickel and chromium, but iron is admitted to the third grade as an alloy.

Only electric furnaces are used in this foundry for the mixing and melting of the metals as there is no other apparatus with which this could be done. The melting equipment consists of one 2-ton arc electric furnace of the heroult type, two induction electric furnaces and three crucible-type resistance furnaces. This is double the amount of equipment that might be considered necessary in a foundry casting other metals in the same tonnage quantity. The heroult furnace is seldom used as impurities cannot be reduced in it as easily as in the other furnaces. It is used only for the larger melts in which impurities are not of such great importance.

Fig. 2 shows the induction-type electric furnace that is used for melts that must be free from impurities. A second furnace just like this is located on its left so one furnace can be relined or rebuilt while the other is working.

The metals used for making these alloys are chromium free from all impurities except iron; electrolytic nickel and a small amount of shot nickel; and for the third alloy 99.7 per cent pure iron is added.

Carbon must be kept out of these alloys as it increases their tendency to oxidize at high temperatures. But it is not necessary to use carbon-free chromium as small amounts of this element will burn out of the metal which is held in the electric furnace at around 2800 degrees Fahr. for about an hour. Only the purest grade of iron obtainable may be used in the alloy that contains iron to keep out carbon, and also sulphur, phosphorus and other impurities. Oxygen, nitrogen, hydrogen or any of the occluded gases are equally as bad. All of the impurities mentioned cause breakage, peeling and other troubles when drawing this alloy into wire or rolling it into ribbons for resistance.

The process of making electrolytic nickel causes it to pick up some hydrogen. A small amount of shot nickel seems to reduce this hydrogen and that is the only reason for its use. It is hazardous to use more than a small percentage of shot nickel which carries more impurities than the electrolytic metal. An English method of making pure nickel does not use the electrolytic process and this nickel does not contain hydrogen. When it is used good nickel-chromium alloy can be made without using any shot nickel, and this is the safest method to pursue. Considerable care also is taken to keep everything dry that comes in contact with the molten alloy, or surrounds it, as moisture might cause it to pick up some hydrogen.

The induction furnace shown in Fig. 2 is given a new magnesite lining each time it is cooled. It is usually operated for three or four months before it has to be relined with brick. As it only requires 40 kilowatts to keep the metal molten over night this is usually done, and in this way a new magnesite lining does not have to be given the furnace much oftener than once a week. As the alloys shrink about the same as steel, the ring of alloy in the furnace would be liable to crack if the furnace got cold over night. Such cracks would interrupt the electrical flow and the ring of metal would have to be taken out of the furnace and broken up for a new melt.

A melt in the induction furnace generally consists of from 550 to 650 pounds.

FIG. 1—UPPER LEFT—REPRESENTATIVE COMMERCIAL CASTINGS—FIG. 2—BELOW—INDUCTION TYPE FURNACE

FIG. 3—UPPER RIGHT—MOLDS FOR CASTING RINGS FOR STARTING MELTS ARE DRIED BY HEATED RESISTANCE WIRE

From 325 to 375 pounds of this is usually drawn off into the ladle for each cast. This leaves a heel of from 225 to 275 pounds to start a new melt. In that way each melt can be drawn off in less than two hours, or five melts in nine hours.

The mold shown in Fig. 3 is used for casting a ring with which to start a new melt in a cold furnace. An idea of the size of the furnace can be obtained from the depression in this mold, which is 6½ inches deep, 5½ inches across the top and 44 inches in outside diameter. About 400 pounds of alloy is cast in this ring and several are kept in stock for emergency use.

A novel method of drying the mold is shown by the wire coil laying on top of the mold at *D*, Fig. 3. A coil ½-inch in diameter is made from resistance wire and this is formed into a ring large enough to fit the bottom of the mold. It is then wired to an electric lamp socket and dropped into the mold. When the current is turned on the resistance wire gets red hot and the mold is covered with firebrick to retain the heat generated by the coil. Such coils easily and quickly can be made to fit any mold and they get the heat to the spot where it is needed without heating up a lot of other materials as well. The mold is dried in a short time and wooden flasks and bottom boards are not dried out or burned in doing it; neither does the mold have to be moved to an oven.

Fig. 5 shows the resistance-type electric furnace that is used for melting in crucibles any metal or alloy that has a melting temperature below 1800 degrees Fahr. This furnace holds two crucibles. Another furnace of the same kind can be seen to the left of this one and still another, of a smaller size, is located at the left of that. This is a handy and cheap furnace to operate where small melts of high grade metals or alloys are required for castings.

The heating chamber is merely a cube that is open on top. The heating elements are nickel-chromium wire coils that are built in the firebrick which surround the heating chamber. The cover is swung into place and lowered by one movement of a lever. The shell is made of angle iron and sheet metal.

One of the peculiarities of these alloys is that while nickel is attracted by the magnet, the addition of 15 or 25 per cent of chromium makes a nonmagnetic alloy, then the addition of 25 per cent of iron brings back the magnetic properties.

Before pouring the alloys into ingots the molds must be thoroughly dried and heated. Three ingots are poured from one ladle. Fig. 6 shows the molds ready to be poured, also the ladle drying apparatus.

The three gas burners at *F* are held over the ingot molds by a gas-pipe stand in a portable base that rests on the floor back of the molds. These burners are located so the gas flames will shoot to the bottom of the molds. They get their gas and air through flexible hose, from overhead pipes. Also burners are arranged to shoot gas flames against the outside of ingot molds. In this way the molds are kept hot after the ingots are poured to prevent them from cooling too quickly or from getting chilled on the outside.

Hot-top rings, made from cast-iron tubes which are lined with about 2 inches of molding sand are shown at *H*. These are baked on top of the furnace and also heated with the gas flame before pouring the ingots. By using these and heating the molds, the pipe was reduced from 30 per cent to about 10 per cent.

The ladle is dried and heated at the same time as the ingot molds. A motor-driven blower which blows the flame for drying the ladle is shown at the right. This is so handy and inexpensive that another motor-driven blower was located at *L* to dry the ladle used with the heroult electric furnace shown in the background at the right. In Fig. 4 the molten alloy in the ladle is shown being skimmed just before pouring into ingots.

Pouring funnels, *P*, Fig. 4, are molded

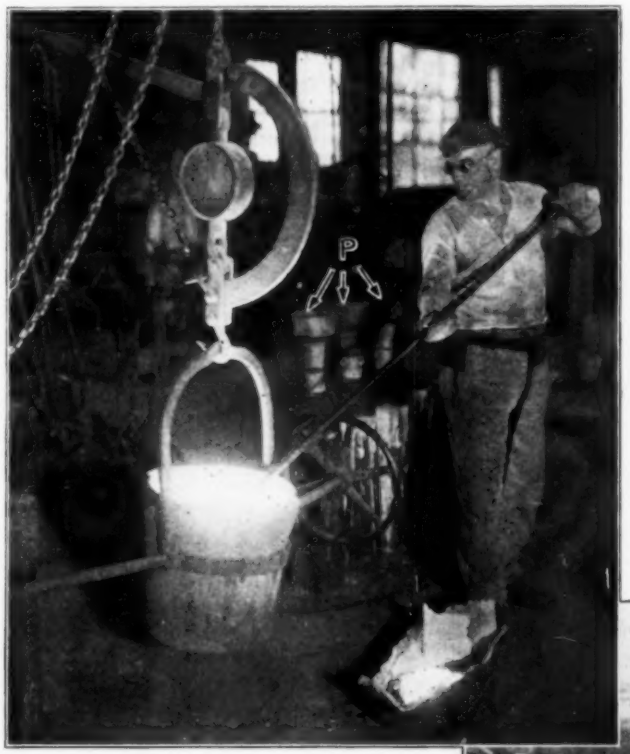


FIG. 4—METAL IS CAREFULLY SKIMMED BEFORE BEING POURED

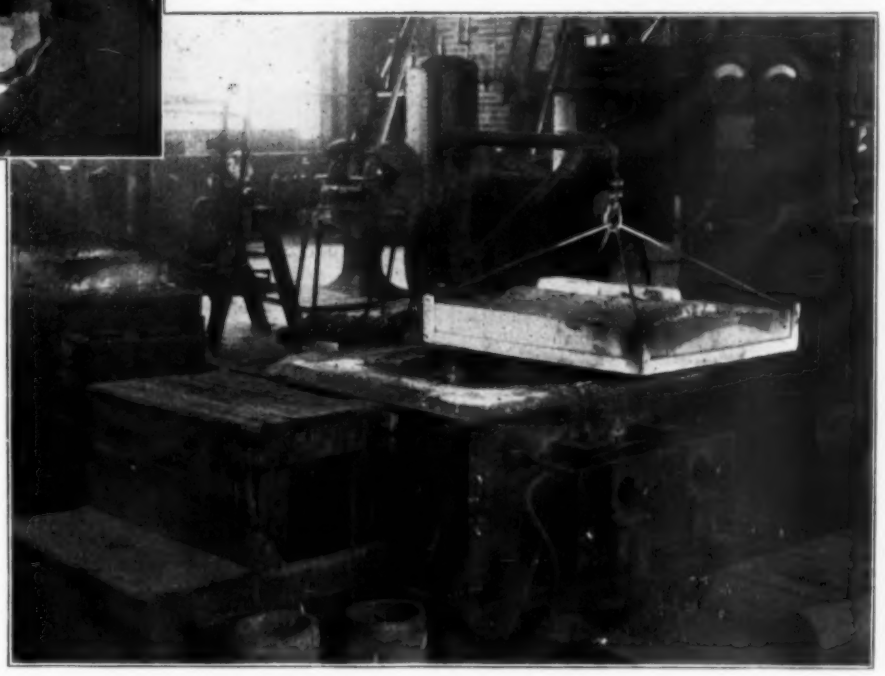


FIG. 5—ELECTRIC FURNACE FOR METAL FOR EXPERIMENTAL CASTINGS IN CRUCIBLES

of graphite. They are then thoroughly dried and heated on top of the furnace. After being skimmed the alloy is poured through these funnels to guide the stream to the center of the molds and keep it from striking the sides. If the molten metal is allowed to run down the sides of the molds it causes streaks in the sides of the ingots. Such streaks are liable to peel off, or sliver, when the metal is rolled or drawn. This alloy is kept close to a temperature of 2800 degree Fahr., until it is poured into ingots.

A few characteristic castings made of these alloys are shown in Fig. 1. The long, flat casting at the right is a hollow shell with metal ¼-inch thick all over. It is some 40 inches long, 16 inches high and 3 inches wide on the outside, and has a hollow center for a water jacket. The core was vented through six ¾-inch holes that can barely be seen on the top edge.

The ability to cast ¼-inch metal over such a large surface would indicate that the alloy flows freely and does not chill quickly enough to cause cold shuts. No wrinkles of any kind could be seen on the surfaces of the costing to indicate even a starting of cold shuts. Chaplets had to be used to hold the core in position and the casting showed that these fused readily with the molten metal poured into the mold. The extremely small vent holes for the core would indicate that this alloy was not of a highly gaseous nature. Of course, the core must be made from materials that will not generate much gas.

The closed-end tubes shown in Fig. 1 usually have a 1-inch core with ¼-inch of metal around it but a smaller size also is made. The longest tube shown is 40 inches long and considerable trouble was encountered when the company started to make them. The greatest difficulty was to anchor the long core so it would not sag or float. These tubes are cast in pairs, with no risers, unless the ¼-inch vent holes, shown by the rods on each side of the sprue in the pair marked *S* could be called risers.

The box casting at the left, Fig. 1, is shown as it leaves the mold. At the right of it may be seen a box with its cover, which has been cleaned and is ready for shipment. The largest of these is 16 x 18 x 24 inches on the inside.

The molds for these castings are made in practically the same way as are molds for steel castings, unless it be that more care is taken to get them thoroughly dry to prevent hydrogen from attacking the molten alloy.

The cast metal has a tensile strength of from 28,000 to 35,000 pounds per square inch, a reduction of area of from 2 to 6 per cent and an elongation in 2 inches of from 1 to 2 per cent. The chromium content raises the strength over that of pure nickel, increases the hardness and refines the grain structure.

FIG. 6—INGOT MOLDS ARE DRIED BEFORE BEING POURED—NOTE THE BURNERS OVER THREE OF THE MOLDS

Freight rates on burned foundry from Springfield, O., to St. Bernard and Lockland, O., during the period of federal control were unreasonable to the extent they exceeded 70 cents prior to June 25, 1918, and 90 cents thereafter, an examiner for the interstate commerce commission finds in a tentative report on the complaint of the American Radiator Co. against the director general.

Cash Prizes Offered by British Foundrymen

Arrangements have been completed covering the special competitions which will be held at the International Foundry Exhibition at Bingley Hall, Birmingham, England, June 15-24. These competitions will be open to all foundry employes, also to ex-service men undergoing foundry training and to technical school students in Great Britain who are under 21 years of age on May 15. The competitions have been organized by the Institution of British Foundrymen and the British Cast Iron Research association in conjunction with the local committee. Among the competitions and the prizes which will be awarded are the following:

For making the best oil sand radiator core and water cooled cylinder core, first prize £3 3s, second prize £2 2s, donated by the National Light Castings association.

For making the best pipe work core or arm core and tooth core for gear wheel, first prize, £2 3s, second prize £2 2s, presented by the Rt. Hon. Lord Weir.

For making the best port core for steam engines or pumps and the best strickled core; first prize £3 3s, second prize £2 2s, presented by the British Engineers association.

Three sets of prizes of £5 5s and £2 2s and each will be given for the best specimens of floor molding, two-part flask molding and three-part flask molding, these prizes being donated by the Rt. Hon. Lord Weir, the Worshipful Company of Founders and the Institution of British Foundrymen, respectively.

For making the best pattern according to a blue print design to be supplied to each competitor, this competition being open to competitors over 21 years of age employed in shops or at school, four prizes ranging from £5 5s to £1 1s will be presented respectively by H. Lakin-Smith, Esq.; J. E. Fletcher; H. L. Reason; and Thomas Vickers. For a similar pattern-making contest to students under 21 years of age, prizes of £5 5s £3 3s and £2 2s will be presented, respectively, by Eagland & Co.; H. Field, president of the Birmingham branch of the Institution of British Foundrymen; and THE FOUNDRY.

Two prizes of £3 3s and £1 1s given respectively by W. Waters Butler and Thomas Vickers also will be given for a patternmaking contest engaged in by students in any technical school within 10 miles of Birmingham.

How and Why in Brass Founding

By Charles Vickers

Free Running Metal

We are experiencing difficulty casting a metal trade mark consisting of one large letter with two smaller ones interspaced in the openings. We are using a composition of 92 per cent lead and 8 per cent tin, but as this does not run well we would like to receive suggestions in regard to a better formula.

A cheaper metal than the one now being used is the following alloy frequently used for letters and trays:

ALLOY FOR LETTERS

	Per cent
Lead	87
Antimony	13

If this alloy leaves anything to be desired in running qualities, use the following:

FLUID LETTER ALLOY

	Per cent
Lead	80
Antimony	10
Tin	10

Aluminum Produces Gas from Water in Sand

Occasionally we have trouble with a ham boiler, a casting shaped something like a wash boiler, which we make in considerable quantities in our aluminum foundry. It is molded bottom up and the metal enters through a single wide gate at the lowest point of the mold. We use No. 1 ingot aluminum strengthened by 5 per cent copper added through the medium of a 50-50 alloy. Occasionally the castings come out with glossy spots on the bottom and when these spots are brushed on the wire wheel they develop into small holes. The holes do not penetrate the casting but they spoil the appearance and force us to scrap it. A peculiar feature is that one boiler may show defects and a second may not, although both are poured from the same spot. Many theories have been advanced and many remedies have been tried without success. Copes have been vented and left unvented without apparently exercising any effect either way. One theory has been that core sand mixed with the molding sand is responsible and another is to the effect that the aluminum has been burned. However, authorities do not agree on the subject of burned aluminum. The consensus of opinion seems to be that the burned or oxidized part would be skimmed off after the application of the chloride or zinc. We believe the trouble lies in the alloy although we cannot prove it. We run along fine for some time and have no trouble and then get one or two heats that run so bad we have to scrap the castings. We use plenty of chloride of zinc and no slag remains on the surface of the aluminum. We pour by pyrometer and we know the metal is not over heated. New metal is the best we can buy and a chemical analysis of the castings proved that the trouble is not there. We shall appreciate an expression of opinion.

The difficulty undoubtedly is due to gas, either air carried into the mold by the almuinum, or gas generated at the spots where the holes are found. Aluminum is such a viscous metal that it frequently carries air down into the mold in the form of bubbles which later appear near the surface under a thin film of metal. A large diameter sprue which cannot be kept filled while pouring aids in the formation of these bubbles. It might be well to examine this possible cause of your trouble first. Watch the pouring-off gang for a few days and if any molds are poured more slowly than others, mark them and note if the castings show any gas holes. In addition to the speed of pouring the height of the ladle above the sprue also must be observed. While pouring aluminum, the pot should be held as close to the runner as possible. The metal is so light and viscous that if any air is carried down by the falling metal it will be found later in the casting.

Aluminum is far from being understood thoroughly in spite of years of experience with it as a casting proposition. Normally it is a well-behaved metal, but it is one of the most chemically active elements known and it is wonderful that such a powerful chemical should be so easy to use and cast in the foundry. It never must be forgotten that it can be irritated into peculiar behaviour. Ordinarily and while cold it will not decompose water, if it did this to any great extent while molten it could not be cast in green sand molds. However, contact with certain substances will irritate the cold aluminum into activity when it easily will decompose water. Mercury and even a little silver nitrate will produce this effect and in fact so will many other substances. If the molten aluminum on its arrival in a green sand mold decomposed the water in the sand the castings would be filled with hydrogen holes. Therefore watch your chloride of zinc additions and never use more than is required to remove the dross. Chloride of zinc has a peculiar effect on aluminum. In connection with carbon which exists in the walls of the crucibles and which also may be found on the surface of metal melted in an iron kettle, it will cause the aluminum to take up nitrogen and form nitride. The zinc chloride acts as a catalyzer, therefore instead of using plenty of zinc chloride, use it sparingly and not too often. If the mold does not draw-air in the pouring then the holes are caused by some condition of the aluminum that produces gas from moisture in the sand.

Aluminum can be burned or oxidized like other metals, but it develops an exceedingly high temperature in combining with oxygen and is used to reduce oxides of other metals to the metallic state. When it is held in a crucible in a brass furnace at too high a temperature, the aluminum drosses away forming a mixture of oxide and nitride depending on the atmosphere. Carbon and chloride of zinc aid in the change, therefore in melting operations the three things that change aluminum should never be associated, these are: temperature, carbon and chloride of zinc. The last two frequently are there but will cause no trouble in moderate amounts and at a low temperature.

Casting Aluminum Plates

We are casting an aluminum frame, or number holder, for automobile numbers, and below the numbers is the name of the town in cast aluminum. The weight of the entire frame must be 12 ounces and we wish to finish the frame in a dark colored paint with the name in a bright color so it will stand out well. We have difficulty in securing smooth castings in No. 12 aluminum alloy as many shrinks and pinholes appear on the surface. Could you advise a mixture that would give smoother castings, and be better for painting? Brass is too heavy; a cheap mixture of aluminum will do as the castings are subjected to no strain.

All alloys of aluminum will be the same as far as taking paint is concerned, and they will all run with as many shrinks and pinholes as the No.

12, alloy, which has the reputation of being the easiest casting alloy of aluminum for sand molds. To get smooth castings is not difficult, it being mainly a question of fine sand. If the foundry sand being used is coarse, it is necessary to get a barrel or two of fine sand and use it for a facing. Any foundry supply house will be glad to suggest a suitable sand; consult the advertising columns of THE FOUNDRY. A cheaper metal than No. 12 alloy can be used and will be just as good; in fact, it is a little stronger. We suggest a mixture of aluminum, 82 per cent; copper, 3 per cent; zinc, 15 per cent. Melt together 6 pounds of 50-50 copper-aluminum hardener, with 79 pounds of aluminum and add 15 pounds of zinc. The cause of the pin holes is no doubt hot pouring. Experiment to determine just how cool it can be poured and run the castings.

Second Test Bar May Be Cut from Casting

In determining the tensile strength of aluminum castings is it considered a satisfactory test to remelt the casting and pour the metal into test bars. A controversy has arisen over the tensile strength of a casting. The purchaser considers it is quite proper to remelt the casting and pour a test bar and to base the strength of the casting on the record furnished by this test bar. We contend that the accepted method is to base all calculations on the metal actually in the casting and that results secured from remelted metal do not furnish a true indication of the tensile strength of the original casting.

Metal is changed to some extent each time it is melted, therefore a test bar made from a remelted casting is not a reliable index to the strength of the original casting. Where a second test bar is required it must be cut from the casting in dispute and this can be done regardless of the thickness of the casting or its size. It is more difficult to calculate the results of the test and express them as pounds per square inch but it can be done and the laboratory making the tests will instruct how to cut out the bars. To properly represent a casting the test bars should be poured from the same pot. In some cases the test bars are attached to the casting. However, if the test bars are not the same thickness as the casting they will not, in the case of aluminum alloys, represent the casting unless provision has been made in the mold for solidifying the test bars at the same time as the casting. For instance, in the case of a large, thin casting and test bars of standard size and shape. The natural place for a molder to place his test bar pattern is near the sprue with the result that the test bar fails to show the required strength and the casting is rejected. The next step, if a second test is allowed, is to cut a bar from the casting, or from one of the castings, for such a test only can be made when the acceptance of a number of castings depends on the showing made by the second test bar. The castings probably will pass the specifications easily. The metal solidifies quickly in a thin section while in the heavier test bar it cooled slowly.

In the case outlined in the inquiry a second test may be made by melting the casting, provided the procedure is agreeable to both parties. Such a test bar will not represent the casting unless great care is exercised all through the operation. A clean crucible must be used and the metal should be broken so that it can be packed into the pot without showing projecting points sticking up into the fire. It must be melted at a temperature no higher than absolutely necessary. The test bar molds should be made from the same sand as the original casting and the pouring temperature of the metal should be controlled by pyrometer. If the casting was thin in section and had to be poured with hot metal, it would never do to pour the test bar, of comparatively heavy section, at the same temperature. It must be poured at as low a temperature as will easily run it, otherwise it would not be a fair test. It is apparent that if the casting and test bar each is poured at a suitable temperature to run it, then the period of solidification will be more nearly equal.

Sand for Impellor Cores

We have encountered a core problem. In making impellors the sand we have been using consists of sharp sand 6 quarts; molding sand, 2 quarts; flour, 1 pint, and ¼ pint of linseed oil. This mixture has been successful with impellor cores having a good body of sand, say about ¾ to 2 inches in thickness. Now we have an impellor, to make with a core only ½ inch thick and 15 inches diameter, and this core mixture blows all the time. The metal is 88-10-2, and when we break up the castings, it seems the core has all gone to pieces. We invite your suggestions in regard to a more suitable mixture.

We suggest the following mixture of sand. Dry sharp sand preferably silica sand, 6 pounds; dry new molding sand, preferably No. 2 grade, 2 pounds; linseed oil, 3 fluid ounces. Mix the dry sands and the linseed oil thoroughly, then add water to bring to the proper degree of moistness. This sand is weak when green and must be supported on a molding sand bed until dry, unless the core is so shaped that it does not require such support.

Cores made with flour and linseed oil as binders blow easily, especially if they are made with plenty of water in the sand. The linseed oil alone, or linseed oil substitute, will make a strong core, also a core that has sufficient permeability to allow the escape of the gases generated while the metal is being poured. The cores should be thoroughly vented.

Alloy for Long Sleeve Is Not Balanced

We are making bushings 6 feet long, 8 inches diameter, 1-inch wall and weighing about 750 pounds each in the rough. The mixture consists of copper 89 per cent, tin 7 per cent, zinc 3 per cent, lead 1 per cent. The castings are spongy, in fact the more metal we cut from the outside the spongier the metal appears. We also find that the white metals segregate and show up in the risers. We add about 1 pound 10 per cent phosphor copper to each 100 pounds of metal. The metal is melted in oil-fired crucible furnaces and is covered with charcoal and borax from the time it is melted until it is poured. We enclose a piece of the exuded metal for observation.

The exuded metal is a rich alloy of copper, tin and phosphorus, containing approximately copper, 79.13 per cent; tin, 19.99 per cent; phosphorus, 0.34 per cent by analysis. Usually this will not liquate in the case of an alloy with as low a tin content as 7 per cent and the reason it does so in this case is because the alloy is not properly balanced. It is rather an unusual alloy, particularly for bushings, but we are unable to suggest a more suitable alloy as no data are furnished regarding the ultimate use of the bushing. A similar alloy, but one that is more evenly balanced follows:

BRASS FOR BUSHINGS

	Pounds
Copper	90.00
Tin	6.50
Zinc	2.00
Lead	1.50

Place 1½ ounces phosphor copper per 100 pounds alloy in the bottom of the crucible with the cold copper and melt together. If the present alloy has to be used, it will be advisable to decrease the amount of phosphor copper to 0.25 per often are due to faulty molding practice cent as a maximum. Porous bushings and if the substitute alloy given is tried and fails to produce sound castings, it is time to begin a study of the mold and molding materials with particular reference to the manner of gating.

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This ... cut into two sections, 5 x 7 inches, and may be readily bound in note book form.

ROUTINE ANALYTICAL METHODS

(*Continued from Data Sheet No.* 430)

Standardization—Solutions should be standardized against either an iron of known chromium and vanadium content, or a sample of iron to which a known amount of chromium or vanadium, or both, has been added. In the latter case, a sample of the iron without addition of either chromium or vanadium should be put through the entire procedure in order to accurately determine the amounts of standard solutions required by the added chromium or vanadium.

Blanks—Careful and accurate determination of blanks is the secret of successful use of this method for routine determination of vanadium. The formation of the blue iron ferricyanide which marks the end point of the titration is affected by concentration of iron salts, as well as presence of chromium, nickel, copper or cobalt. Consequently the number of c. c. of ferrous ammonium sulphate required by the sample if no vanadium were present, in other words, the blank, will vary with the weight of iron taken as sample, the volume at which titration is made, and amounts of chromium or nickel present. For the ordinary routine work giving accuracy within 0.03 per cent, the variation of the blank with the weight of the sample, maintaining a constant volume at titration, is all that needs to be determined. The blank will vary from 0.6 c. c. for a 1 gram sample to 1.5 c. c. for a 5 gram sample.

Notes and Precautions—The use of potassium ferricyanide as internal indicator was developed by C. M. Johnson.

The equivalence of the ferrous ammonium sulphate and potassium permanganate solutions is best determined under conditions similar to those at which actual titration is made, that is, by comparison in the solution of a sample after chromium has been titrated, provided that vanadium be not present.

Presence of vanadium may be detected as a rule by the fading of the first pink of the excess $KMnO_4$ when titrating chromium. This is due to comparatively slow re-oxidation of the vanadium in cold solutions. If solution be not cold, there is a tendency to re-oxidize chromium also. If vanadium be absent, the first flush of pink is usually permanent.

(*Continued on Data Sheet No.* 432)

ROUTINE ANALYTICAL METHODS

(*Continued from Data Sheet No.* 431)

Care must be taken not to overrun the pink end point, especially if vanadium is to be determined. The first glint of pink in the high lights reflected from the bottom of the beaker is to be taken as the end point, not the first pink that permeates the entire solution; otherwise the error will be cumulative in the vanadium titration.

For routine work, the vanadium value of the solutions may be taken as three times the chromium equivalent. For instance, by adding c. p. potassium dichromate to a sample of iron, a value of 1 c. c. equivalent to 0.085 per cent chromium is obtained. The vanadium equivalent of 1 c. c. would then be 0.255 per cent.

DETERMINATION OF TITANIUM IN CAST IRON

Colorimetric Method

Principle—This method is based upon the fact that a solution of sodium peroxide, added to an acid solution of titanium produces a yellowish orange coloration the depth of which color is proportional to the amount of titanium present. Amount of sample taken for analysis should be such that there will not be more than 5 milligrams of titanium in the colored solution. Iron, vanadium and chromium also produce colors with sodium peroxide and are apt to cause error unless allowed for.

Solutions

Sodium Peroxide—Dissolve 4 grams Na_2O_2 in 125 c. c. 1-3 H_2SO_4 and dilute 600 c. c. with water.

Standard Titanium Solution—Dissolve 0.25 gram of a carbonless ferrotitanium of known titanium content in 30 c.c. 1-3 H_2SO_4. When dissolved, oxidize with the minimum amount necessary of conc. HNO_3. Boil, cool and dilute so that 1 c. c. contains 0.005 gram titanium, representing 0.1 per cent on a 5 gram sample. When making a determination, dilute one volume of this solution to 10 volumes with water. One c. c. then represents 0.01 per cent on a 5 gram sample.

(*Continued on Data Sheet No.* 433)

Malleable Anneals Not Packed

Pot With Flange at Both Ends Is Developed To Prevent Gases From Entering and Attacking Castings—Temperature Must Be Kept Low To Eliminate Warping When Castings Are Not Supported

BY EDWIN K. SMITH

NO GREATER improvements in control of processes have been shown in recent years than those developed in the malleable castings industry. Time honored customs have been replaced by new methods, and guess work by scientific control. Just now, another landmark is being obliterated, and packing material, heretofore thought essential to the process, is being abandoned. Since

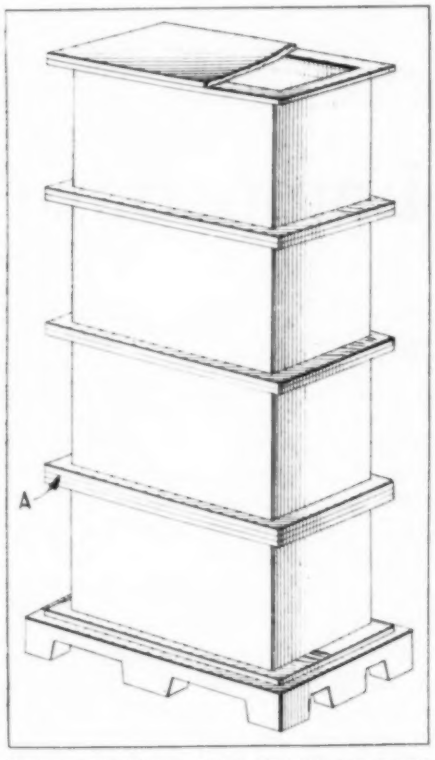


FIG. 1—DETAILS OF A STACK OF POTS

the infancy of the industry, the change from hard white iron to the malleable form has been credited, in a great degree, to the action of the packing in which the castings were annealed. Not so many years ago it was the custom to use some form of iron oxide, usually mill scale, and after each anneal the packing material was moistened with a weak solution of sal-ammoniac to *rust* it. Unquestionably, such compounds had, and still have, certain advantages due to their chemical activity at high temperatures.

During the past ten years or so, the tendency has been away from this active form of packing, and inert substances such as ashes, rolled furnace slag, ground brick, sand, etc., have been more generally used. These materials have the advantages of low cost and permanence. They protect the castings from flame, and by their support, prevent distortion at high temperatures.

Several years ago, the writer conducted experiments with a view to eliminating packing material altogether. It soon became evident that such substances were in no way essential to the production of good mallebale. Doubtless others were of the same opinion, and in some foundries the use of packing probably has been reduced, or eliminated. However, the use of packing has been the accepted practice in the industry as a whole. In fact, the statement still is heard that satisfactory castings cannot be made without some special form of packing material.

On taking up the experiments the first question which presented itself for solution was whether the strength of the castings would be reduced if no packing were used. To determine this a large number of bars were annealed, half of them with packing and their duplicates without packing. No differences were observed, and all the bars passed usual specifications for malleable castings.

The next problem was to establish the process on a commercial production basis. This resolved itself into a search for a suitable annealing pot. At first pots cast with a cope, so that both top and bottom edges were quite smooth were tried. When stacks of these pots were thoroughly mudded up, this form of container gave good results for a few anneals. But when the pots began to sag out and the edges were eaten by flame, it became impossible to maintain a perfect seal between the pots in a stack. Frequently during the anneal openings would appear between pots and oxidizing gases from the oven would enter. These gases oxidized the castings to such an extent that they had to be scrapped.

The next course tried was to cast a flange on one end of the container. When such a pot was filled with castings, mud was spread on the broad upper flange, and another pot was placed on this, narrow edge down. The mud made a good seal, and it appeared as if this solution of the problem, would be satisfactory. But when these pots had been through the anneal many times, the unflanged edge, being much thinner than the other, began to bulge out, while the flanged edge did not. The result was

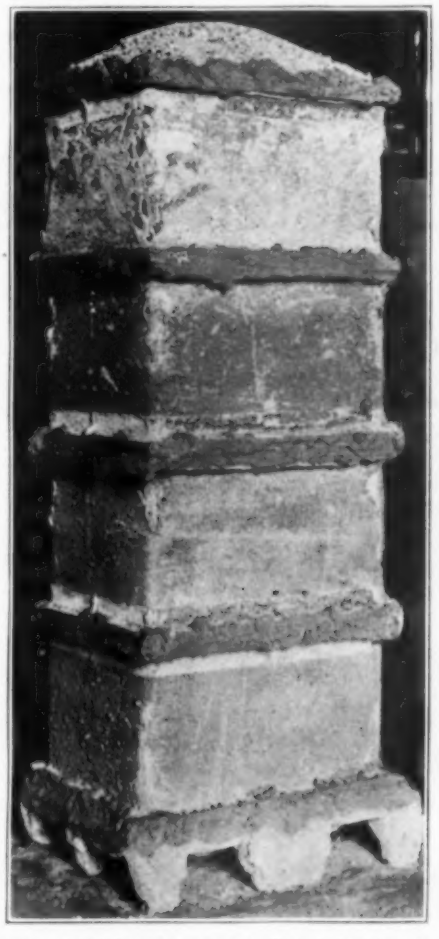


FIG. 2—THE STACK IS WELL LUTED AT THE JOINTS

a loss of time in fitting the pots together to get a flameproof seal.

Finally we made a pot with two broad flanges. These gave results satisfactory to us and were patented. Although this type is rather more difficult to cast, the additional cost is not great.

In stacking them the first pot is placed on a stool, the upper edges of

The author is metallurgist, Lakeside Malleable Castings Co., Racine, Wis.

which has been coated with mud. The pot is then filled with castings without the use of packing material. Mud is next spread over the upper flange of the pot, and another pot is placed on top of this. The two broad flanges, with mud between them, form the seal. As many pots as desired are thus superimposed, and a plate is similarly sealed on top. Sand or ashes are placed on the plate in order to protect it from the direct flame.

The heavy flanges on the pots retard bulging to a marked degree. When they finally are almost burned off the pot can be used with packing for several more anneals if desired.

One difficulty that may be encountered at first is from warping of light castings which the packers have been accumstomed to support with packing. This might seem to be serious, but in fact is easily remedied, mainly by use of dividing plates, as shown at *A*, Fig. 1, and by proper control of oven temperatures. In order absolutely to be safe, a plate can be used between each two pots at first. Obviously, with no pressure from the contents of the upper pots, castings will not warp unless they are extremely light in section. In such case, two courses are open; either to fill in all the spaces between the larger castings with some of the smallest size, or to use packing.

In the ordinary type of annealing oven it is advisable to use packing in those pots nearest to the firebox, as they are exposed to higher temperatures than those at other places in the same oven. In the average run of light malleable work one can use packing for castings which are liable to distortion and also in pots near the firebox, and still be able to eliminate 75 per cent of the packing.

Either with or without packing, pyrometer equipment is almost essential. For a while after the change to annealing without packing is first made the furnaceman who has been accustomed to heating tons of packing material is apt to overheat the oven. For this reason it is desirable to use a two-point recording pyrometer on each oven. One couple should be placed in the corner farthest from the firebox near the floor, this being the coldest part of the oven. The other couple should be located next to the firebox on a level with center of the top pot, as this is the hottest part of furnace.

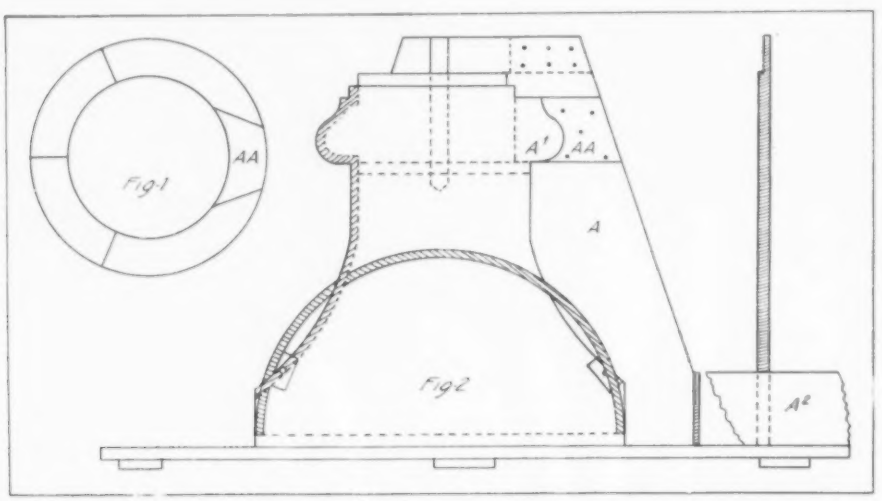
It is of course desired to keep the temperature of the hottest point as low as possible while maintaining proper annealing conditions at the coldest point. For the hot point 1700 degrees Fahr. is satisfactory, but no serious warping will be found if the top temperatures do not exceed 1800 degrees Fahr.

Some of the readily apparent advantages of annealing without packing are that dust in the annealing room is reduced; labor is saved in loading and dumping the pots, also in the tumbling and sand-blast departments, as castings are almost clean when received; and less fuel is required and the oven is brought to temperature quicker because there is no packing to be heated.

Plaster Pattern Used for Lamp Base

BY THOMAS NELSON

RATHER peculiar circumstances surrounding the lamp base casting shown in the accompanying illustration rendered the job more interesting than ordinarily would have been the case. Only four castings were required and it was essential that pattern expense be held to a minimum and yet the pattern had to be constructed in a sufficiently substantial manner to withstand the comparatively rough usage incident to being rammed up and drawn out of the sand four times. We decided to sweep the pattern and corebox in plaster of paris, but since the metal thickness was only 5/16-inch we were obliged to make pattern and corebox separately. The pattern was made first by constructing a substantial wood frame and sweeping a thickness of plaster on the outside conforming to the shape of the desired casting. On account of the shoulder on the small end of the pattern the core designed to form the inside of the casting was made in 6 sections with the idea of lowering them into place and then pushing them toward the wall of the mold after the shoulder on the core cleared the shoulder on the pattern. The corebox was made by inclosing one sixth of the outside circumference of the pattern in a frame, taking a plaster impression, adding the necessary thickness and adjusting the edges on radial lines. The three internal bolt lugs on the large end of the casting were formed by a loose piece used on three cores and omitted from the others The corebox was made 1 inch longer than the pattern at the small end and 2 inches wider at the large end, but we realized afterward that the large print should have been made wider, probably 3 inches all around.



INSTEAD OF A SHELL PATTERN THE PLASTER FOR THE OUTSIDE WAS SWEPT UP ON A SUBSTANTIAL WOODEN FRAME—THE CORE WAS MADE IN SIX SECTIONS AND ONE ADDITIONAL NARROW KEY SECTION

A wood coreprint the full size of the core at the small end was nailed to the frame on which the plaster pattern was swept. This print was provided with a pin in the center on which the sweep revolved. The molding, or shoulder, on the small end was formed in the following manner:

The sweep first was employed with a loose piece as shown at *A* 1, to form a seat. After this had dried, the loose piece was removed and the ring forming the shoulder was swept in place. This ring, later was cut into five sections in the manner indicated in Fig. 1 to facilitate its withdrawal into the mold. The section *AA* was marked in a suitable manner so that the molder should

draw it first and each of the sections was provided with a large block of wood bedded in the plaster to facilitate handling. These blocks were provided with a number of projecting nails on one side to reinforce the plaster and on the front side with a rapping hole by which to loosen the pattern from the sand. The sectional view of the sweep *A* 2, shows a piece of board about 12 inches long fastened to the bottom. This piece rides on the board on which the pattern is swept and keeps the sweep true and perpendicular as it is revolved around the spindle.

The shop usually employed 50 molders, but at the time this job came in the only men working were two molders, the cupola tender and the foreman. A small homemade cupola, 12 inches inside diameter, furnished all the metal required for the light intricate castings on which they were engaged. To secure an ample supply of hot iron we decided to take a small heat off in the regular cupola and pour all four castings from the one ladle.

A number of square flasks 3 x 3 feet were assembled to make the four drags which then were rammed and rolled over. The plain flat copes were rammed on a board. A gate pin was rammed in each of the four corners of the cope and after the cope was tried on the drag, a pinch of flour served to show the location of the gates in the drag. Three branches were cut under the bearing surface of the core at each corner. Under ordinary circumstances a bull ladle would be employed at each corner, but in this instance, for lack of help to handle the ladles, we built a basin on the cope leading to the four upright gates and poured the casting from a crane ladle.

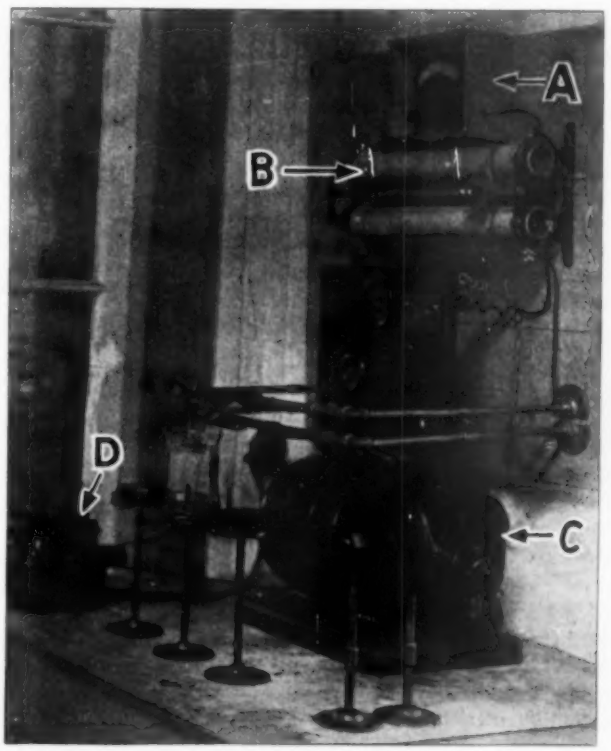
An iron plate under the small, or bottom print, served to support the cores and also facilitated sliding the cores forward into place. With only 5/16-inch thickness it is apparent that setting the cores was a delicate operation. We found that the 1-inch core bearing around the top was not sufficient to support the heavy overhanging cores and had to insert stem chaplets supported from the sides of the flask. To make room for setting the last core we filed away one edge of the first core and the adjacent edge of the sixth core and filled the gap with a narrow core made by placing 2 stop-off strips in the corebox. The joints of all the cores were daubed and the space inside the assembled cores filled with rammed sand. After the castings were poured we removed the copes, dug out the centers and cut away the cores at two opposite points to permit contraction of the casting.

Electrolytic Apparatus Proves Efficient

EFFICIENT electrolytic equipment for determining copper and lead in brass, and nickel in steel, used by Frank H. Cole, chief chemist, Walworth Mfg. Co., Boston, is shown in the accompanying illustration. By stirring the solution through revolving the beaker copper and lead determinations in red brass are made simultaneously from the same solution in an hour and a half. A half-gram sample in a nitric acid solution is used. In making nickel determinations the nickel is deposited on a platinum electrode, the other electrode being a passive iron wire. In this determination the solution is strongly ammoniacal, containing about 20 per cent by volume of ammonia. The time necessary for the determination using a half-gram sample is about an hour. Thus determinations are made much quicker than where no method of agitation is used and in about the same time as would be required if revolving electrodes were used.

The electrodes are held by clamps attached to pieces of brass pipe through which the electrolyzing current passes from a small low-voltage motor-generator set, *C*. The beakers containing the solutions to be analyzed, which are the ordinary 240 cubic centimeter type, are held by springs on wood pulleys. The pulleys are revolved by small fan motor, *D*, which has a speed of approximately 1600 revolutions per minute. As the speed of this motor is excessive a counter shaft is used to reduce the speed of the beakers to 160 revolutions per minute. A greater speed would cause the liquid in the beakers to be thrown out.

The motor-generator set consists of a 110-volt, 60-cycle, single-phase motor, and a 15-volt 10-ampere generator. The current is regulated by a sliding resistance, *B*, and a rheostat attached to the panel underneath the sliding resistance. The rheostat is operated by the knob shown in front of the panel. The ammeter is also on the rheostat panel, being part of the motor-generator set. The volt meter is shown at *A*.



RAPID DETERMINATIONS ARE MADE ELECTROLYTICALLY USING EQUIPMENT WHICH REVOLVES THE BEAKER

The rheostats control the current on the entire line and as the electrodes for each solution are run in parallel they all have the same voltage. Thus nickel determinations which are made with 6 amperes and 14 volts cannot be made at the same time as copper determinations for which 1 ampere and 2 volts are used. If only one copper determination is made the current must be cut down to 1 ampere while if three copper determinations are run simultaneously the rheostats must be regulated to furnish 3 amperes.

Making Centrifugal Castings

Method of Producing Hollow Metal Objects Is Described—Uniform Cooling of Poured Metal Makes Manufacture of Thin Tubes Possible—Believes Process May Be Applied to Plate Making

BY LEON CAMMEN

CENTRIFUGAL castings of metals is an old art but did not assume importance until the last decade. Since then, however, while it did not attract much notice, its progress has been rapid. It has already become a factor in such industries as the manufacture of paper mill rolls and railroad car wheels. It is today the most vital problem before the makers of cast iron pipe in the United States, and, with the most recent developments, promises to revolutionize the two most profitable lines of the steel industry, that is tubular goods and plate manufacture. In the present article it is intended to describe the process of centrifugal casting of hollow metal objects. However, the field of centrifugal casting is far more extensive. This process has been applied successfully in the production of nonmetallic tubes, such as concrete pipe. It has been used also for the production of solid castings by locating the molds around the rim of a spinning wheel, and also to a small extent for the production of solid ingots by a process largely similar to the above.

The field of application of centrifugal casting is far more extensive than is generally realized and is already worked on a large scale. In the first place, centrifugal casting is a cheap method of producing goods of certain shapes, namely, those having a hollow interior symmetrical about an axis passing through the body of the casting, whether concentrically or eccentrically. The advantage of such methods lies in the fact that with proper equipment a large number of units can be produced with comparatively little labor and without the use of cores, and that a greater homogeneity of metal is secured than could be obtained with ordinary casting. During the war several concerns employed this method, for example, for the production of piston rings for automobile engines, and even now some establishments continue to use it for that purpose.

The Sandusky Foundry & Machine Co., Sandusky, O., employs centrifugal casting to produce bronze paper-mill rolls and propeller sleeves which would be much more expensive and probably less satisfactory if cast in a stationary mold. The Stokes Casting Co., Ltd., Mansfield, England, has used the same method for making cast iron liners for aluminum cylinders of internal combustion engines of such a small thickness and high grade of metal as could not be duplicated by any other process except machining, and at a price only a small fraction of what a machined tube would have cost.

Put Process on Production Basis

In the field of cast iron pipe centrifugal casting is in a fair way to displace sand-molded pipe entirely. The method of centrifugal casting of cast iron pipe has been developed primarily by a Brazilian engineer, Dimitri Sensaud DeLavaud, and has been extensively employed in England, Canada and Japan. Some months ago the United States Cast Iron Pipe & Foundry Co. of Burlington, N. J., one of the largest manufacturers of cast iron pipe in the world, acquired the DeLavaud patents for America and are going into the manufacture of centrifugally cast iron pipe on a large scale. It is stated that they can make 600 lengths a day with 25 men and the centrifugal process, as against 400 lengths with 80 men by sand molding, in addition to which centrifugally cast pipe is roughly 15 per cent stronger than sand cast.

Another development in centrifugal casting which has already become of commercial importance is the manufacture of railroad wheels as carried on in this country, for example, by the American Steel Foundries. The idea itself is not new and there are English patents describing it dating back to the early sixties. In 1882, Webb, speaking before the Iron and Steel institute stated that at his works in Crewe he was casting steel wheels and making them sound by casting them on turntables. This was, however, a fairly crude process applicable only to plain steel. As cast centrifugally by the American Steel Foundries, the wheel has a manganese steel rim and a soft steel hub and spokes, the depth of penetration of manganese in the rim being regulated at will. Considering the difficulty of casting such an article as a wheel without rupturing it during cooling, the development is of considerable engineering interest.

Of late, centrifugal casting acquired a further importance in the development of a method by which tubes and hollow billets were successfully cast of such metals as monel metal and alloy steels, which can neither be cast into thin-wall tubes nor pierced by the ordinary methods. Recent developments in the art are such as to open really great possibilities for the future, a matter which will be discussed in a later part of this paper.

The art of centrifugal casting of hollow metal objects is quite old and has been practiced on a commercial scale since the beginning of the last century. The earliest English patent of Eckert dates as far back as 1809 and the earliest American patent to Lovegrove was issued in 1848. At about the same time Andrew Shanks, in London, England, began to make cast iron pipe 12 feet long and 3 inches in diameter by pouring molten metal into a spinning wrought iron mold. His process was described in America in the *Scientific American* of Dec. 1, 1849, ad it is of interest to note that in its basic features of design the Shanks machine does not differ in any way from the great majority of machines working with a cold mold in this day.

Rotation Clears Steel of Air

Attempts were made at an early date to apply centrifugal casting to ingot making with the view to improving the quality of the metal and, for example, M. Tresca, in a paper before the Institution of Mechanical Engineers, states that the most remarkable instance that he had met with of freedom from air bubbles was in the case of a bessemer rail manufactured at the Imphy Iron Works near Nevers in the department of Nievre;

From a paper which was presented at the meeting of the American Society of Mechanical Engineers at Atlanta, Ga., May 8-11. The author is associate editor *Mechanical Engineering*, 29 West Thirty-ninth street, New York, and is also connected with the Centricast Tube Corp., 61 Broadway, New York. An early description of the centrifugal casting process, as developed by the author, was described in the Oct. 1, 1921 issue of THE FOUNDRY.

and he had ascertained that the method adopted at these works was to pour the molten metal into a revolving vessel driven at a considerable speed so as to clear the steel of air by rapid rotation. This method proved effective in practice in freeing the steel from the minute air bubbles which it contained on leaving the converting vessel or the melting pot.

A survey of the literature and of the numerous patents issued on centrifugal casting in this country and in Europe, would indicate that practically all the essential features were covered by patents issued prior to the beginning of the twentieth century, with the exception, however, of those dealing with the temperature control of the metal, which is a new feature. It would appear, therefore, that with the exception of minor details and one or two features in special casting processes there is no reason why any good engineer could not design and operate a successful casting machine with a nonheated or noncooled mold without running into legal complications. At the same time, it might be well to realize that the fact that the basic features of the general process are already free makes those who have developed some of the few minor features particularly anxious to protect their patent rights in them. Because of this a general familiarity with the patent situation is desirable to avoid involuntary infringement by using some minor details such as, for instance, a particular type of pouring spout that has been covered by a patent.

Mechanics of Centrifugal Casting

In the first place, a clear distinction should be made between casting made with the horizontal and with the vertical axis and also the intermediate case of an inclined axis. In casting about a horizontal axis the metal is distributed symmetrically about the axis of rotation, and if the axis of rotation coincides with the axis of the spinning unit, a tube of uniform thickness is produced for the entire length of the mold. If a vertical axis is used it is obvious that the external wall of the casting follows the shape of the mold while the interior of the casting forms a paraboloid of revolution, the elements of which depend on various factors. In casting with the inclined axis the same general principles apply with the further complication that the elements of the inside paraboloid of revolution are also affected by the angle of inclination of the axis to the true horizontal.

The usual way of casting is by introducing molten metal into the spinning mold. Where the chilling of the metal is extremely rapid, as for example, in casting cast iron pipe against a water-cooled chilled mold, it is imperative to use a movable spout, the latter sliding at a certain predetermined rate so that by the time the nozzle discharging the metal comes out of the mold the entire pipe is completed. This is the process employed by DeLavaud. Other manufacturers working with the cold mold have attempted to secure the same results by what is known as a trough spout, which is really a trough into which the entire metal of the casting is poured at a rapid rate. The trough is then tipped and discharges the metal suddenly, the metal falling on to the walls of the mold at such a rapid rate that a pipe forms before the metal has had time to chill. Hitherto this process has met with only indifferent success.

A better result has been achieved on comparatively short castings, however, by the use of a ledge spout, the spout ending in a flat ledge along which the metal can flow the entire length of the casting. Finally where a hot mold is used, an ordinary short spout is employed, the metal distributing itself throughout the mold longitudinally under one of the components of centrifugal pressure or pressure produced by centrifugal action. This arrangement cannot be used with the cold mold for reasons explained in the appendix.

In centrifugal casting the distinction should be clearly made between jobbing work and mass production. For the former, clay molds in iron cases have been used practically exclusively as it would not pay to make a permanent mold for only a few castings. When it comes, however, to production on a tonnage basis, such as tubing or pipe, a permanent mold is practically the only feasible way of doing it. Crucible graphite or zirconium tubes have been successfully used for castings not in excess of 3 feet but when it comes to longer length, metal molds are to be preferred. Fairly successful results have been obtained with chrome-nickel alloys though it is not expected that this will be the material finally adopted, as enough work has been done already on the production of cast tungsten to make it certain that a mold of this still rather mysterious material will be available within a comparative short time.

Various Supporting Methods Used

Several methods are used for supporting the mold in the spinning bench depending on whether the mold is a permanent fixture or removable and also depending on the size of the mold. Where the mold is a permanent fixture as it is today wherever a cold mold is used, any kind of bearings, providing they are substantial enough, may be used. With removable molds the conditions are somewhat different, especially where the mold is heated to a high temperature. It will be shown later that the temperature of the mold at the time of pouring the metal may be as high as 2000 degrees Fahr. Where extremely hot molds have to be used the arrangement must be such that the stresses on the mold could be reduced to a minimum, and that the mold could be rapidly and easily inserted into the machine and extracted therefrom. The matter of stresses is of great importance in view of the fact that, especially in large machines, the bursting stresses due to the action of centrifugal force are of such magnitude as to require the most serious consideration.

Explanation of Spinning Bench

The spinning bench for such removable molds as shown in Fig. 1 works on a comparatively simple principle, the mold being held in a barrel rotating on rollers on which the pressure is adjusted by the wheel and screw shown at the top of the A-frame. This does not show the method of supporting the mold, in addition to which, except for the small sizes, three rollers are not sufficient. The barrel construction shown in Fig. 3 is far more suitable for use with hot molds. Here the barrel consists of a steel shell, *b*, as shown in Fig. 1 which may be an extra heavy steel pipe, but in sizes above 12 inches has to be made as a special casting. At four to six places symmetrically spaced along the inner circumference of the shell, steel strips tapered at *m* and *n* and with faces machined to the same radius as that of the internal surface of the shell, are screwed on or riveted on. The strips are provided with truncated slots as shown in the figure, and in these slots move the keys or gibs *o*, the cross section of which is shown by *k* and *j* which indicates that the face *j-k* is of the same width from one end to the gib to the other, but the height of the trunk varies.

It is obvious that as long as the four gibs move through the same distance longitudinally in their tapered beds, the faces of the gibs will remain parallel to each other but the inclosed cylinder tangent to those faces will vary in diameter with the position of the gibs.

The operation of the machine described

therefore in detail follows: The head, designated as *i*, is opened and the gibs pulled out a little way until the tangent cylinder is about ¼-inch larger than the external size of the mold. The mold is then inserted, preferably without touching the gibs, until it comes to bear against the abutment ring, *e*, to which all the gibs are attached, for example, by hooks, *f*.

As the mold presses against the abutment the latter recedes and carries with it the gibs, which by moving in their tapered beds gradually contract until they come to grip the mold, and they may be made to grip it as hard as desired simply by exerting sufficient pressure on the abutment, *e*, which may be done through the block, *g*, by the screw *h*.

Shrinkage Determines Mold Type

The important advantage of this construction lies in the fact that, first, the mold automatically finds its own center; and, second, that it is supported all along its length, a matter of great importance when we come to deal with the bursting stresses in the mold. Whether a solid or a split mold should be used is a matter determined primarily by the shrinkage condition of the metal of the castings and the metal of the molds. Where the shrinkage conditions are such that the casting comes out of the mold easily, that is, where it contracts quicker than the mold, a solid mold may be used, but where the shrinkage conditions do not guarantee easy extraction of the casting, or where the shrinkage conditions are nonuniform the use of a split mold has been found advisable. Such molds are usually split longitudinally and the question of the best method for holding the two parts together is far less simple than it appears at first sight. There are numerous patents showing the two split parts of the mold held together by bolts. In actual construction, however, the use of bolts for this purpose is entirely unsuitable as may be shown by the following simple calculation.

Assume that a standard 6-inch pipe, weighing 20 pounds per foot is being cast in a mold 6 inches inside and 8.8 inches outside diameter, weighing 100 pounds per foot and that the spinning speed is such that each pound of metal exerts a centrifugal stress of an average of 100 pounds. The total stress per foot of length of mold is, therefore, 120 x 100, or 12,000 pounds, and this stress has to be borne at the bolts. If there are two bolts per running foot of mold, each bolt has to carry 6000 tons. According to *Machinery's Handbook* to carry such a stress the bolt, cold, would have to be 1⅛ inches in diameter. Even such a bolt would be impossible to put into a wall 1¼-inches thick, which has been assumed above, but at 2000 degrees Fahr., which is the temperature at which the mold may have to work in the hot mold process of a centrifugal casting, the metal of the bolt has not more than 20 per cent of the strength that it had when cold. This means that either bolts of prohibitive size would have to be steel or the operation of a split mold held together by bolts would be extremely dangerous.

To meet this condition the mold shown in Fig. 2 has been developed. This mold has side lugs machined in such a manner that when the two parts are put together a tapered structrue, such as *d*, is obtained, and dovetail pieces, *c*, are provided to engage with the taper *d*. It is obvious that when the dovetail piece, *c*, is driven hard over the lug taper, *d*, it will hold it tight. Furthermore, both the lugs and the dovetails can be made within reason practically as heavy as desired, so that a good factor of safety can be provided to take care of bursting stresses in the mold. To close or open the mold, it is only necessary to apply pressure to the dovetail piece or give a light blow, and by means of a simple jig to the blow or pressure can be applied to all the dovetail pieces on the mold at once.

Such a construction diagrammatically is shown in Fig. 2. It is obvious, however, that the presence of the lugs makes the machining of the mold to a true cylinder expensive, if not impossible. Because of this, instead of machining the mold to a cylinder, a number, such as four, of flat faces are planed on the mold, the location of the faces being such that they would be distributed symmetrically around the longitudinal axis of the mold and that they should be tangent to a circle described with the point on the axis of the mold as a center. Such an arrangement is comparatively easy to carry out and it gives an excellent support for the mold besides providing a structure of good dynamic balance properties.

Must Withstand Vibration

As regards the foundations and bearing for centrifugal casting machines no special design need be described here, but it should be most clearly and strongly emphasized that both the bearings and the foundations should be of generous proportions and most substantial design. The machine in centrifugal casting is subject to quite violent strains and unless it is properly built it is apt to get into vibrations which sooner or later may have a dangerous effect. The writer knows of a case in an American plant where a centrifugal casting machine located in a ditch and built with insufficient ruggedness actually jumped out of the ditch during operation and endangered the lives of those around it. With steel and concrete amply available there is no excuse for such practices.

Up to about two years ago little work, as far as the writer knows, had been done successfully on the problem of casting centrifugally comparatively thin sections, say, under ⅜-inch, in such metals as steels, or monel metal and in lengths beyond 3 feet. On the other hand, large castings in brass, bronze, cast iron and even steel have been made with considerable success. The reason for it lies in the failure to understand the thermal conditions in the mold and the process underlying the freezing of the metal.

There is a basic difference between casting in a stationary mold and in a spinning mold. In making castings in the former, whether it be a simple ingot or a complicated casting from pattern, the foundryman has means to provide for the escape of gas from the metal and for taking care of the cavities produced by contraction in cool-

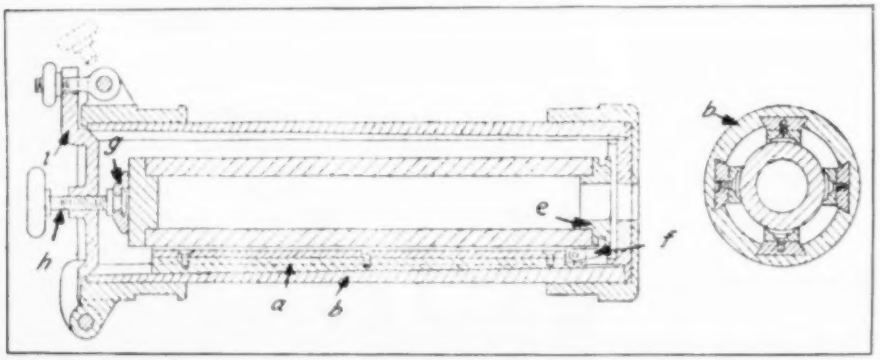


FIG. 1—CROSS SECTIONAL VIEW OF HEAVY-TYPE SPINNING MACHINE USED WITH REMOVABLE MOLDS

ing. In a casting from a pattern, sink heads are provided, while in an ingot casting the top of the ingot acts as a sink head, in addition to which special methods such as dozzling may be used to keep the top of the ingot hot as long as possible, and increase the efficiency of the ingot top in performing the functions of the sink head in molds. In both cases the foundryman is prepared to discard as defective a certain part of the casting including the ingot head, risers and sink heads and his skill lies partly in reducing the quantity of discard as far as possible and especially in directing the process so as to restrict the presence of defective metal to the parts which he is prepared to discard.

Casting Cools Uniformly

In centrifugal casting, however, there is no riser or anything corresponding to the ingot top, and the cooling proceeds essentially at a uniform rate all along the length of the tubular shape. It is obvious, especially in tubes of small diameter and considerable length, such as 6 inches outside diameter and 16 feet long, that the loss of heat inward must be extremely small, because the entire inner air cylinder is surrounded by metal at approximately the same temperature. Heat is therefore lost mainly outward to the mold and through it to the air. As a result of this, the part of the casting in immediate contact with the mold chills first. The problems with which the "centrifugal" foundryman has to deal are essentially the same as those which confront the man pouring into stationary molds, and these are, first to get rid of the occluded gases, and, second, to take care of contraction cavities. As regards occluded gases and slags, it would appear at first sight, especially to those familiar with such centrifugal processes as cream separation, that they would be eliminated automatically; pure metal, being heavier than either slag, or metal containing gases, should be thrown to the outside, against the wall of the mold, while all impurities should go to the inner wall. This does actually happen, providing one condition is satisfied, and that is that sufficient time is available; and it should be remembered in this connection that this separation takes place at a fairly slow rate because of the great viscosity of molten steel.

The second problem is that of cavities formed in the casting as a result of contraction in cooling. As stated above, the part of the casting in immediate contact with the mold chills first. In doing so, it contracts, and

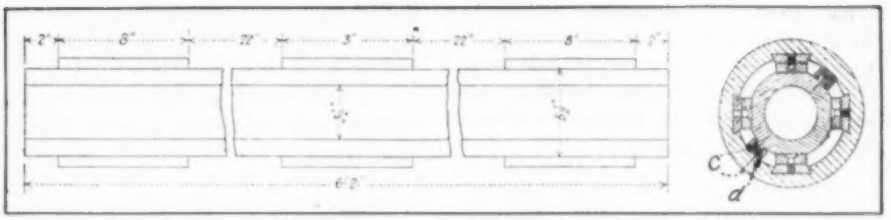


FIG. 2—A VARIATION OF THE MACHINE SHOWN IN FIG. 1 HAVING A SPLIT MOLD HELD TOGETHER BY TAPERS AND DOVETAILS

if left to itself, might easily form contraction cavities and thin spots. However, if the rest of the metal is still in a liquid state, it is projected with a pressure at the rate of say 100 pounds per pound of metal, against the chilled layer, and fills all possible cavities with an efficiency many times greater than can be obtained with sink heads in stationary casting. To obtain the same results in a stationary mold, it would have been necessary to put into the sink head 99 pounds of metal for every pound of metal in the actual casting. This again presupposes, however, that the cooling proceeds at a fairly slow rate, and enough time is available for each succeeding layer to take care of chill conditions in the preceding layer. In cold-mold centrifugal casting, which means with a mold warmed enough only to take off the chill, say 300 to 400 degrees Fahr., temperature conditions do not favor slow cooling, which is one of the reasons of the many past failures to produce thin-wall steel tubing by centrifugal casting. On the other hand, excellent steel tubes both plain carbon and nickel alloy have been produced with diameters ranging from 10 inches up, and wall thicknesses up to 3½ inches. In the latter case there is so much metal in comparison with the area in contact with the mold that enough time is available to produce a good segregation of impurities inward before the inner wall freezes.

Mold Is Highly Preheated

It would appear, therefore, that the secret of producing centrifugally thin metal castings under ½ inch lies in establishing conditions under which the cooling of the molten metal would proceed at a fairly slow rate. This of course applies only to such metals as steels and monel metal, but not to bronze, which is governed by different conditions. In the Cammerr process this has been accomplished by preheating the mold to a temperature close to the melting point of the metal itself, which may vary from, say 1600 to 2000 degrees Fahr. for steel and monel metal castings. Under these conditions a 3/16-inch wall takes about 45 to 60 seconds to harden entirely, which is sufficient to produce clean metal. Casting in such extremely hot molds is a rather novel procedure and at first one might anticipate trouble due to oxidation and warping of the molds and the difficulty of handling big molds conveniently.

Few Difficulties Encountered

As a matter of fact, however, with proper equipment it offers comparatively few difficulties. The question of oxidation of molds is taken care of by using proper alloys, such as alloys of a nickel-chrome base or cast tungsten. The latter is not yet being done on a commercial scale. The question of warping is taken care of partly by the same use of proper alloys, but mainly by the use of extremely substantial molds and proper facilities for handling them between the casting machine, the transfer table and the furnace. In all this handling, the molds have to be properly supported throughout the entire length either by carrying them on a very heavy horn extending from one end of the mold to the other or in a cradle supporting the mold throughout its length.

The method of operation is as follows: The mold with its casting inside, both at a temperature well above white heat, are rapidly pulled out from the casting machine and carried over to what is known as a transfer table, where the casting is pushed out of the mold by a hydraulic plunger. While the casting is going to the proper rolls or benches, the mold itself is coated inside by a protective layer and carried over to a reheating furnace. The furnaces used in this connection do not differ essentially from the billet-heating furnaces in tube mills. The mold coating is intended to protect the metal of the mold from coming into direct contact with the molten metal of the casting and need not be more than, say, 1/64 to 1/32 inch thick. It consists of some refractory material like alumina, zirconia, kaolin, electrically calcined magnesia, or the like. Either pitch with some addition of solvent naphtha or clay may be used as a binder, the former being preferable as it contains no water. The coating may be applied either by a swab or through a compressed air gun.

The transfer table referred to above cannot be described here owing to lack of space. It is a somewhat cumber-

some piece of apparatus which may weigh from 2 to 10 tons, depending on the sizes of the castings handled, and is a practically self-contained unit operated from a cab by pulling a series of levers one after another.

Application of Hot Mold Castings

The particular feature that determines the field of application of hot mold centrifugal casting is the ability to produce cast shapes of comparatively thin metal down to ⅛-inch in great length, with our present knowledge of the art up to 20 feet. One of the first applications that comes to mind is in the production of seamless tubing.

Hitherto the principal tonnage of seamless tubing has been made by the Mannesmann piercing process and its variations. Essentially this process consists in imparting such a twisting motion to a steel billet as to break down its central fibers. This motion is set up by means of obliquely placed rolls or disks. There are several objections to this process. In the first place while it does pierce high grade mild steel or Muntz metal billets, it stresses the central part of the billet far beyond its elastic limit. While apparently this does not affect seriously the tensile strength of the finished product after it has been cold drawn or hot rolled, there is good reason to believe that it impairs the resistance of the metal to corrosion, the latter, as we know now, being particularly active in the case of metals stressed up to or beyond the elastic limit.

Furthermore, the Mannesmann process is not at all applicable to metals which are either extremely tough or brittle. Thus, all attempts to produce commercially by the Mannesmann process, hollow billets of either monel metal or admiralty brass have so far failed. Not only that, but the Mannesmann process, by its very character is limited to the production of comparatively small sizes, not in excess of 6 inches in diameter; while experimentally larger sizes have been made, the 6 inch limit has been well established for standard commercial grades. It is obvious that as we go up in sizes, the piercing mills used in this process increase in cost with great rapidity and as the cost of even a small Mannesmann mill easily runs into six figures, the cost of the big ones becomes prohibitive after passing a certain limit, which is around 6 inches.

At the same time there is a demand for larger sizes of tubing of greater strength than a single welded joint can give and this is where the most obvious field of hot mold centrifugal casting appears. With this process, tubing in extra heavy and double extra heavy thicknesses can be easily produced in sizes up to 24 inches in diameter at a cost per ton that can compete with plain tubing and it is considerably lower than double welded tubing such as used for hydroelectric installations

The next field of application in connection with steel tubing is in standard sizes from 6 to 14 inches up, where welded tubing is now used exclusively. Such pipe can be produced in two ways: First, by casting a hollow billet of wall thickness two to three times that of the finished pipe, and either cold drawing or hot rolling it to size. In such a case the billets cast would be roughly 8 to 10 feet long so as to have about 22 feet in the finished pipe, barring cropped ends. The other method is to cast the pipe direct with only a slight excess of wall thickness and then to give it one pass between straightening rolls over a ball, so as to reduce the diameter and wall thickness to exact size with standard tolerances, and give the exterior and interior walls a finished appearance. From data now available it would appear that the final cost of both kinds

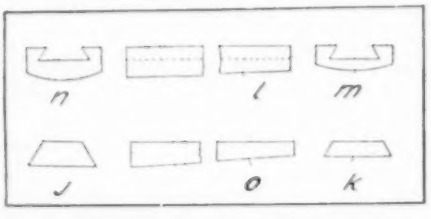


FIG. 3—GIBS AND BEDS OF THE SPINNING MACHINE SHOWN IN FIG. 1

is aproximately the same and is well within the range at which centrifugally cast steel pipe can compete in price with welded pipe.

Material Handling Is Reduced

It is only natural that this should be so. In pipe manufactured by the standard processes, steel is cast in ingots, which, after cropping and several thermal and mechanical operations, are rolled into skelp. The skelp goes to a pipe mill, is heated to red heat and rolled to bevel edges after which it is sent through the bending rolls. It is next reheated to welding heats and in succession passed through welding rolls, sizing rolls and finally straightening rolls. Each of these operations is done, of course, by apropriate machinery developed to a remarkable high state of perfection, but nevertheless each operation adds its mite to the final cost of the article, and this mite is not inconsiderable in view of the immense tonnage produced. In centrifugal casting the metal is poured into the mold which corresponds to casting the ingot, and the casting is then ready to go to the final rolls which can be done without reheating. There is at least 50 per cent less handling of material in centrifugal casting than there is in marking pipe by welding and such a difference cannot help being reflected in costs.

Some Distrust Prevails

In this connection it might be well to mention one of the psychological factors with which centrifugal casting is concerned, and that is, the not unfounded distrust of users of metal products towards castings, especially those in thin sections. Such castings cannot be produced commercially in a stationary mold, and steel castings in a stationary mold as made today generally are of such physical properties as to be usable only where they are not subject to complicated stresses and where an extremely high factor of safety can be provided. Wherever the stresses are high and especially uncertain and the factor of safety is not more than ample, no engineer today will use a casting but will insist on either a forging or a piece machined or hot rolled.

This not unfounded distrust of castings is due to the fact that in either the sand casting or chill casting the temperature conditions in the metal are uncontrollable, with the result that one part of the metal may be entirely different from the other in its physical properties, such as hardness and crystalline structure, and there is no guarantee that two castings made under apparently the same conditions will be entirely alike. There is too much individuality in products cast in stationary molds to make them suitable for engineering requirements where a failure would be disastrous and where only moderate factors of safety may be employed. However, the situation is entirely different with centrifugal castings, because there ample facilities are available especially in hot-mold casting, to control the rate of cooling of the metal, and the nature of the process is such as to tend to give a uniform product, providing, of course, the process is carried out properly.

But the field of application of centrifugal casting, especially of the hot-mold type, does not stop with plain carbon steels. There are a number of alloy steels which it would be desirable to have in tube form, such as stainless steel, high speed tool steel, chrome-nickel-vanadium steel and the various near-steels, which means iron alloys with a predominance of materials other than iron, such as heat-resisting alloys. Practically none of these materials will stand for piercing by the Mannesmann process, but cast with great ease into tubular shapes. In fact, by centrifugal casting, even Hadfield manganese steel has been found to make excellent tubing although it is doubtful if it

has any commercial application outside of some limited specialties.

Centrifugal casting is peculiary applicable to manufacture of plates. Andrew Shanks, the British inventor of the middle of the nineteenth century, to whose pioneering work in the manufacture of cast iron pipe reference has been made, was also the earliest manufacturer of plate. His process was to cast a thin-wall pipe, cut it, and then by careful annealing and hammering, flatten it out. The process was kept secret and was successful commercially until rolled steel sheet was put on the market.

The use of a hot mold makes it possible, however, to secure comparaticely thin-wall castings in large sizes. A process has been worked out, though not yet applied on a commercial scale, in which a cylindrical casting is made in such a manner that a longitudinal split of about ½-inch wide is produced. The split cylinder as it comes from the mold is sent first through a flattening jig where it is flattened out on its own heat and then to rolls, of which there are at least two, one for sizing and the other for finishing. Under certain conditions more than one sizing roll may be required. The casting has to be cast oversize, the wall thickness being from 10 to 15 per cent greater than that of the finished plate. Thus, for example, ¼-inch plate would be cast in sizes 240 inches long, 20 inches in diameter and 0.265-inch wall thickness. It is expected that it can be brought down to ¼-inch in one pass in the sizing rolls and that no reheating would be necessary.

This process is today only in its initial stages of development. It is attractive, however, as it does away with the ingot casting work, soaking pits, blooming mill and a great share of the rolling equipment, permitting a conversion from molten metal to finished plate estimated at about $4.00 per ton.

Offers Use for Alloy Steel

Not only that, but this makes attractive the manufacture of alloy steel plates, in particular, of such material as acid-resisting steels for use in chemical tanks and the like. These steels are difficult to roll. The final product could stand the cost of the two or three passes necessary in centrifugal casting of plates, but not the many operations of the conventional methods of plate manufacture. The main item of expense being not the actual rolling but the complicated heat treatment absolutely imperative between the rolling operations. In fact, it would not be surprising if with prices of alloy steel plates brought within reason, they would be used far more extensively than one would expect to find from present indications.

The casting of gears by centrifugal methods, in particular worm and herringbone gears, has been achieved with great success both in England and in America, especially in this country. As far as the writer is aware, however, all such gears have been cast in nonferrous metals and not in steel.

Cylinder Production Possible

There is one more field of application of centrifugal casting, especially the hot-mold type, comparativley small today, but which may become of material interest shortly. That is the production of cylinders requiring extremely high strength. When the oxygen industry first called for cylinders that would safely withstand 2000 pounds pressure to the square inch, it appeared to be a big problem, but it was solved by the progress in the cupping process. However, when the Haber synthetic ammonia process demanded great pressures combined with considerable temperatures, special expensive tools had at first to be provided for machining the cylinders required from solid stock. The Claude ammonia process goes to temperatures and pressures far exceeding those of Haber, and the experiments of Professor Bridgman of Harvard university and others point to the likelihood that before many years are past pressures of the range of 100,000 to 200,000 pounds to the square inch and possibly even higher will be used commercially. At pressures between those used by Haber and Claude and those used by Professor Bridgman for containers of commercial size, carbon steels are but little suitable, and the vessels required will have to be made from alloy steels.

This may be done in two ways, either directly by centrifugal casting on a vertical axis which would give a vessel with closed bottom, or by the cupping process from alloy steel plates, which, in their turn, would be made by centrifugal casting as described above. In this connection, it may be of interest to mention that some excellent success was achieved during the war by the Bethlehem Steel Co., Bethlehem, Pa., in casting air flasks for torpedoes centrifugally in a machine running on a vertical axis.

No attempt has been made in the above discussion of the field of application of centrifugal casting to present anything like an exhaustive list. Instances have been merely cited to show the enormous field in which this process is or may be employed. The same applies largely to the description of the mechanics of the process, where likewise no attempt has been made to show the historical development of machinery for centrifugal casting or to give details of the actual apparatus.

In connection with the mechanics of centrifugal processes it is appropriate to say that the machinery itself is and should be comparatively simple and the process when properly worked out is the acme of simplicity. However, it should be understood clearly that in centrifugal casting we are dealing with large rotating masses and with metal subjected in its molten state to the effect of great force. Furthermore, the distribution of the metal in the mold is effected primarily not by rigid material visibly distributed as in stationary casting, but by the action of invisible forces which do not come into operation until the moment when the metal is delivered to the mold.

Because of all this, and notwithstanding the great simplicity of the machinery and methods of centrifugal casting, it should be remembered clearly that even the slightest imperfection in the design or operation will show up immediately in the casting.

There is an old saying current among molders to the effect that a lie in sand will be shown up in the metal. The same with still greater force applies to centrifugal casting. The slightest mistake in the layout of the machinery or use of poor materials in the machine, its bearings and foundations, will produce an uneven casting, result in excessively rapid wear of the molds, and at times may even cause disastrous accidents with danger to life. At the same time, with good engineering and the use of first class materials, centrifugal casting may be carried on entirely by semiskilled labor and still give products of unsurpassed excellence.

A Correction

In the description of the German molding machine, page 324 THE FOUNDRY for April 15, it is erroniously stated that it was shown at the foundry convention and exhibition held at Liege, Belgium, Sept. 18-Oct. 10, 1921. The statement should read, the convention and exhibition held at Exhibition park, Munich, Germany, Sept. 14-25, 1921.

The Chicago sales office of the Whiting Corp., Harvey, Ill., has been removed from 1245 Marquette building to 945 Monadnock building.

How Others Made the Same Job

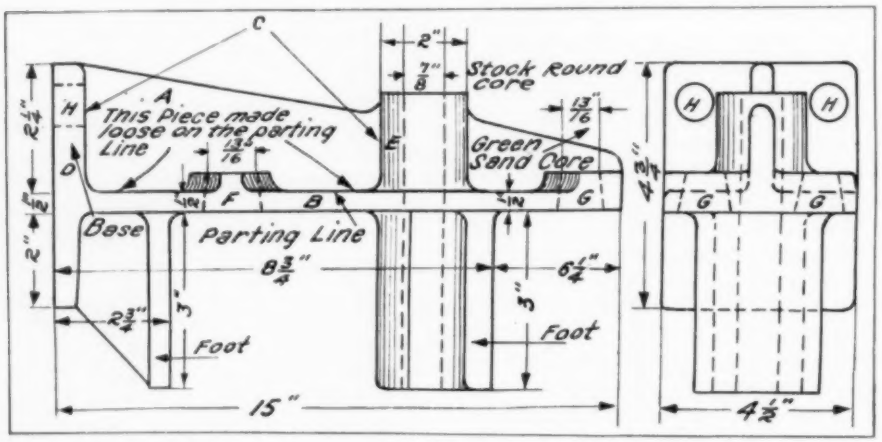
How a Bracket Pattern Was Made—Locating Dowel Pins—Cylinder Trouble Due to Core Mixture—Mold Is Adapted To Serve as Corebox—Decimal Clock Dial Aids in Figuring Time

IF possible the apprentice patternmaker should keep a record of the work which comes under his observation. He should note the sizes and proportions of the work, the method of joining the different parts and the time taken in its production. Finally, whenever practicable he should ascertain whether the castings made from the patterns were satisfactory or not and if defective, make a note to that effect and also note the character of the remedy applied. A pen and ink sketch on the margin will add to the value of such record and also furnish excellent training in the art of making sketches.

The patternmaker must depend on his experience and observation to decide many of the details incident to his daily work. The drawing from which he works shows merely the shape of the finished casting. It does not indicate the amount of finish allowance to be provided at certain places, neither does it furnish any clew to the best method for constructing the pattern or any indication of how it will be handled in the foundry. Furthermore it should be apparent that the time spent on a pattern designed to produce a great number of castings would be wasted if spent on a pattern which was only to be used once. The cast iron bracket shown in the accompanying illustration is an example of this kind.

The first order on this job called for two castings so I made the pattern all in one piece leaving the holes *H H*, *F F*, *G G* to be drilled in the casting. This operation required about 45 minutes for a machinist. Making the parting occupied a little more of the molder's time than if the joint was flat. However, I allowed extra draft on the faces of the hub and base *C* and also on the rib *A* to insure an easy and clean lift in the cope.

Later 50 castings were ordered and that called for a general change in the design and construction of the pattern. The whole top section was made loose and fitted to the lower part of the pattern with dowel pins. This simplified the molder's work to a certain extent.



WHEN ONLY ONE OR TWO CASTINGS WERE REQUIRED THE PATTERN WAS MADE IN ONE PIECE AND THE HOLES WERE DRILLED OVER TABLE AND FLASK.

Core prints were attached to the pattern at *HH* and a core box provided which turned out three cores at a time. Holes through the bosses *G G* and *F F* were cut through the pattern which left their own green sand cores.

These alterations added about $8 to the cost of the pattern; but besides facilitating the work in the foundry, the saving effected in drilling the holes more than offset the added expense.

BY M. E. DUGGAN

Locating Dowel Pins

Patternmakers usually employ one of two methods for locating dowel pins in wooden patterns. In the first instance the center points are determined by a square and gage and then the holes are bored to the required depth. I do not consider this an accurate method. Occasionally it works out satisfactorily, but frequently it does not. In the second method the two halves of the pattern are attached by toe nails in their proper relative position to each other, or held together by a clamp and then the holes are bored through one half, usually the cope and a certain distance into the other part. After the dowel pins are inserted the remaining parts of the holes are plugged. A method, that involves the use of neither square or gage, no troublesome plugs and that is accurate follows:

Select two suitable points on the split face of one half pattern. Clip the heads from two 1-inch brads and drive the brads into the face of the pattern at the points indicated. Leave about ⅛-inch of the brad projecting above the surface. Place the second half of the pattern in position on top of the first and press it down into place, if necessary strike a few light blows with a hammer. Pull the two halves apart, remove the brads and the center points of the dowel holes clearly will be indicated. The brace and bit then is employed to bore the holes to the necessary depth and after the metal dowels are inserted, the job presents a neat appearance with no unsightly plugged holes. It also will be accurate. The idea, of course, can be applied where any number of holes are required.

BY W. J. CARROLL

Cylinder Trouble Due to Core Mixture

Gas engine cylinders scrapped in the machine shop to the extent of 75 per cent of one day's production, started an investigation of an apparent foundry mystery. The machine shop superintendent classified the trouble as dirt in the bore and for a time the foundry superintendent was at a loss to account for the presence of dirt at that point, or for that matter at any point. No changes had been made in the organization, the gating, the method of molding the castings, or the iron mixture. The cylinder pattern, equipped with a skim gate, had been used in this gasoline engine foundry for a number of years and in that time had produced thousands of good castings. Evidently the fault was not with the pattern or the method of gating. Dirt in the bore may be due to cold iron, either by melting it cold or by handling it so slowly that it is below the proper temperature when it is poured. In this instance it was found that the iron was

melted just as hot and handled just as fast as before the trouble occurred.

The cores were examined and they appeared to be satisfactory until tested for hardness. The core room foreman had not changed his mixture and the man in the mixing room stated that he had used the usual quantity of oil and water. Finally it developed that he had opened a new barrel of core oil which presented a white instead of a golden color. Since this appeared to be the only weak link in the chain the superintendent had a new barrel opened and having satisfied himself that it had the right appearance, ordered the first barrel set to one side until the test cores had been made from sand bonded with oil from the second barrel. No further trouble was experienced from dirty cylinder bores.

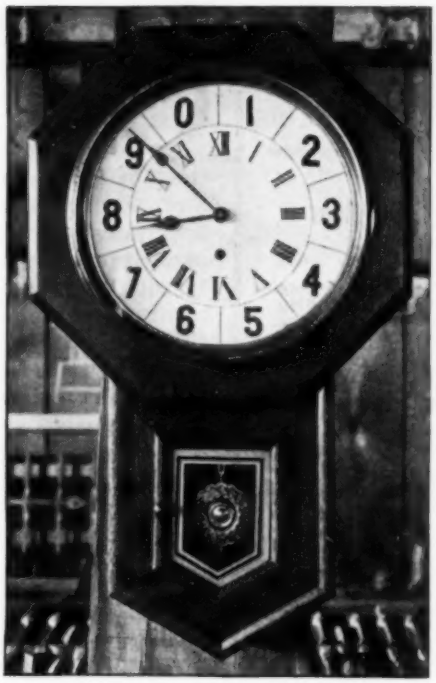
Blowing may be caused by hard cores, hard molds, wet sand or improper venting. Other things being equal, a cylinder core in the skin of which a dent may be made with the finger nail, will be found satisfactory.

Where the core is a trifle too hard, the iron will not lie quietly against it, but will set up a slight boiling action. Where the boiling action becomes violent enough to throw the iron out through the riser, the cause is quite apparent and steps can be taken to remedy the trouble; but in other cases, as in the one instanced, the boiling has ceased before the iron reaches the riser and there is no indication of trouble until the boring tool uncovers a dirty place under the skin.

By H. P. Kreulen

Mold Is Adapted To Serve as Corebox

Changes recently made in one of the breakers used in the preparation of anthracite coal involved the casting of a chute 3 feet long, 2½ feet wide and 7¼ inches deep and with ⅝-inch thickness of metal. On account of the thin section of metal it was considered advisable to make a solid pattern, mold it flat side up and form the interior



THE FACE OF AN ORDINARY CLOCK REPLACED BY A DECIMAL DIAL

with a dry sand core supported on core prints. Before the corebox could be made, an urgent call was received for the casting necessitating emergency action.

An impression was taken of the pattern by laying it face down on a level bed and after the pattern was taken away, a mold for the arbor shown in Fig. 3 was made on the bed. A mold then was made from the pattern in the usual manner and after the pattern was taken out of the drag, strips of paper were laid in the bottom of the mold. The flanges were filled with sand after which the bottom and walls of the mold were lined with clay strips formed in a flat box 4 x 8 x ⅝-inch deep. A second layer of paper was spread over the clay, this was followed by a thickness of riddled sand after which the arbor was lowered into place, gaggered, rammed full of sand and lifted out as shown in Fig. 2. The clay strips were taken out of the drag and after the mold and core had been repaired and blacked the core was lowered back followed by the cope, clamped and poured.

By R. S. Findlay

Decimal Clock Dial Aids in Figuring Time

A novel scheme for simplifying time keeping in plants where records are based on tenths of an hour, is shown in the accompany illustration. The face of an ordinary clock was removed and replaced with one showing both the usual five minute divisions and divisions into tenths of an hour. The time keeper or any one entering time on the decimal system, merely reads the short hand from the inner dial and the long hand from the outer. Thus, the time shown in the illustration is 8.9 o'clock and if a man worked from this time until 11.3 o'clock, the actual time on the job would be easily determined as 2.4 hours. A dial divided into decimal parts of an hour is not new, but it is seldom found on a clock in a manufacturing plant. This particular clock was found in use in the foundry of the Arcade Malleable Iron Co., Worcester, Mass.

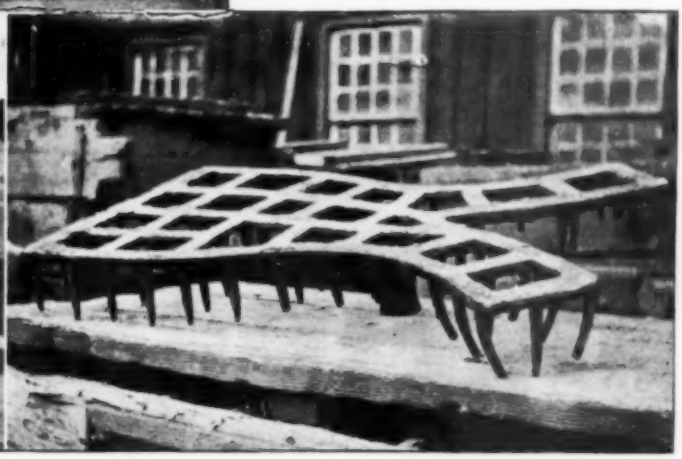


FIG. 1—ABOVE—THE CASTING FIG. 2—AT THE LEFT—THE MOLD AS IT APPEARED JUST BEFORE THE CORE WAS LOWERED BACK INTO PLACE FIG. 3—AT THE RIGHT—THE ARBOR CAST IN OPEN SAND

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Foundries Need Technical Men

OPERATED, in years past, on the rule of thumb method it was essential that foundries should be in charge of a man familiar personally with every step in the production of castings so that he could at once detect and remedy any defect in the molding or melting operations. Then the foundry was small and the superintendent was in touch with every department. Gradually the size of foundries has been increased until now the superintendent must leave much of the direction to heads of the different departments and only have charge in a general way. If a defect is noticed in any castings the superintendent in many cases does not study the details of the operations directly, but discusses them with the head of the department to which they are attributed, or possibly holds a consultation with the heads of the molding and melting departments to decide to which the defect is due. To determine this he must have more than a passing acquaintance with the different steps in making a casting; he must be familiar with theory so that he can weigh cause and effect more intelligently than he could with only a so-called practical knowledge. With the metallurgist talking thermophysics and chemical changes, and with hardness and tensile tests in specifications to meet he must have a fair technical knowledge. Too, the machinery and mechanical appliances now so essential to a large foundry require considerable engineering knowledge on the part of the chief executive, or his staff.

Possibly under these conditions the old route from the apprentice to the molder, the foreman and finally to the superintendent not always is the best for the present day executive. The divisional superintendent on a railroad usually is a technically trained man who has advanced from the engineering branch of railway service. This line of advancement might suggest a similar course for the one who is to direct operations in a large foundry. A contributing factor which recommends such a plan is the fact that it is becoming more and more difficult to secure high class boys to start at the bottom and thoroughly learn the molder's trade. Even if such material could be found the wide use of the molding machine greatly has reduced the field for the skilled molder in light work shops and even the amount of heavy work done by hand is being encroached upon by machines which continually are built in larger units. Even the most intricate jobs can be handled mechanically.

Of course, a technical man in the foundry would be of little value if he had no practical experience and some means must be given him to secure such experience. Of the few executives who have advanced to their position from the technical schools some have worked at molding before starting to college and during the summer vacations. Others have taken the academic work first and then entered foundries as special apprentices. Of these two, the plan which would give the student a better appreciation of the college course, is that which requires foundry training before entering upon his studies. With the practical experience and hard knocks a boy receives as a foundry apprentice he would realize the necessity for getting all out of his college course that he could and he would be able better to select the course of studies to pursue. A combination of theory with practice is needed.

Trade Outlook in the Foundry Industry

NO ONE questions the substantial improvement in practically all lines of castings manufacture. Heralded by an increase in inquiry in March, followed by a steady development in orders through April and into May, foundry business has been increasingly better. The only question now in the minds of manufacturers generally, and foundry managers in particular is, will it last? Some hold that the return has been too rapid, that increased activity will induce higher prices, increased labor costs and the old cycle will return.

Favorable Factors

Were the betterment based on a less secure foundation of general activity, or if the returning prosperity were confined to single industrial lines, better grounds might be had for such apprehension. No sane manufacturer feels that production should be increased recklessly, and yet the means for fixing the limits of normal output are difficult. Few would have been rash enough at the first of the year to predict the growth in automobile manufacturer. Yet April marked the high point in the history of the industry. In consequence automobile castings plants are engaged to capacity. In some of the larger centers, notably Detroit and Toledo, an actual labor shortage is at hand in those plants which specialize in gray iron and malleable castings for the automotive industry. Building construction continues to grow apace. Contracts awarded in 27 northeastern states in April exceeded all previous records, according to the department of commerce. The total floor space contracted in the nine classes of buildings recorded totaled 58,146,000 square feet for April, compared to 51,957,000 square feet for March, and 34,471,000 square feet for April last year. Neither labor factors, material prices, nor financial difficulties seem to threaten this building boom.

Prices of Raw Material for Foundry Use

CORRECTED TO MAY 24

Iron		Scrap	
No. 2 Foundry, Valley	$24.00 to 25.00	Heavy melting steel, Valley	$17.25 to 17.50
No. 2 Southern, Birmingham	18.50 to 19.00	Heavy melting steel, Pitts.	17.00 to 17.50
No. 2 Foundry, Chicago	23.00	Heavy melting steel, Chicago	14.25 to 14.75
No. 2 Foundry, Philadelphia	25.54 to 26.40	Stove plate, Chicago	16.25 to 16.75
No. 2 Foundry, Buffalo	22.00 to 23.00	No. 1 cast, Chicago	17.25 to 17.75
Basic, Valley	25.00	No. 1 cast, Philadelphia	18.00 to 19.00
Basic, Buffalo	23.00 to 23.50	No. 1 cast, Birmingham	13.00 to 14.00
Malleable, Chicago	23.00	No. 1 cast, Buffalo	18.00 to 18.50
Malleable, Buffalo	22.50 to 23.50	Car wheels, iron, Pittsburgh	16.50 to 17.00
Coke		Car wheels, iron, Chicago	18.50 to 19.00
Connellsville foundry, coke	$6.50 to 7.00	Railroad malleable, Chicago	17.00 to 17.50
Wise county foundry, coke	6.00 to 6.50	Agricultural mal., Chicago	17.00 to 17.50
		Railroad malleable, Buffalo	17.00 to 17.50

Freight Cuts Come

With building conditions propitious, automobile and railway demands for castings growing, and an improved tone in municipal, domestic and agricultural buying, a most cheerful factor has been contributed by the announcement of freight rate reductions effective July 1. The interstate commerce commission, in ordering a cut of 14 per cent in eastern territory, 13½ per cent in the west and 12½ per cent in the southern and mountain Pacific regions has supplied a strong stabilizing influence to the present industrial structure. True, the improvement of the past few months has been in the face of continued transportation handicaps, but doubtless many contracts for materials have been held in abeyance and many orders postponed with the possible rate reduction in view. During May, pig iron purchases by foundries have increased in proportion to the greater melt. Southern iron has reached $18.50 a ton, furnace and some iron producers are sold up on foundry grades to Sept. 1. Coke, also has been purchased more freely and stocks generally are ample. An interesting sidelight on the greater demand for coke is furnished by a western car wheel foundry which formerly used only about a car load of coke in two months and which now requires three cars a week.

Rail Orders Continue

While the purchase of new railway cars has not kept pace with the tremendous demand of the close of April and the first weeks of May, additional orders are being placed daily. Further, railroads are placing many bad order cars in shape for the anticipated increase in freight traffic during the summer and fall. Consequently car wheel foundries, and others making railway sundries have experienced a flood of orders. Malleable foundry operations have benefitted by this condition and the average of malleable activity is above 60 per cent of normal. Cast-iron pipe demand is holding up well, supported by private inquiry, although the municipal interest has lapsed, by reason of many cities having filled their early season requirements. Stove and furnace manufacturers are busy and consequently casting demand from these sources is heavy. Makers of builders hardware, plumbing sundries and sanitary ware continue on the up grade, while gray iron jobbing shops with a varied output are in better condition than at any time in the past eighteen months. Manufacturers of paper mill machinery and heavy machine tools constitute exceptions to the general advance in the foundry industry, although sales of the latter class of machinery are steadily improving. Increased steel mill operations, based on the boom in building construction, automobile and railway car building, has brought about capacity operation in roll mills throughout the eastern and mid-western states, some roll foundries being sold up until fall. Steel foundry operations vary largely with the character of the product. Those devoted to light castings, automotive parts and equipment and the iron and steel industry are active and continue to show an increase every week, but some of the general steel casting plants and those devoted to marine lines still are on curtailed schedules.

Nonferrous Prices

Prices for nonferrous metals, based on New York quotations in the *Daily Metal Trade* of May 24, follow: Casting copper, 13.25c; electrolytic copper, 13.75c to 13.87½c; Straits tin, 31.00c; antimony 5.40c; lead, 5.70c to 5.75c; aluminum, No. 12 alloy, producers' price, 19.00c to 19.20c and open market, 16.00c to 16.50c. Zinc is 55.20c, E. St. Louis, Ill.

Personal

Charles Davis until recently brass foundry foreman of the Utah Copper Co., Garfield, Utah, has been promoted to the position of iron foundry foreman for the same company.

Charles R. Spare, inventor of the product manufactured by the American Manganese Bronze Co., Holmesburg Junction, near Philadelphia, and organizer of the company 15 years ago, has been elected its president.

Enrique Touceda sailed for England, May 27 to deliver his paper on American malleable cast iron before the Institution of British Foundrymen. This is the second American paper to be presented as an exchange between the British foundrymen and the American Foundrymen's association.

Homer F. Staley, metallurgical ceramist for the bureau of standards, Washington, has been made ceramic engineer of the Metal & Thermit Corp., New York. He has been president of the American Ceramic society and has been on its board of trustees. He is a member of the committee on ceramic chemistry of the National Research council.

David McLain, McLain's System Inc., will sail for England on the Olympic, June 3. Mr. McLain has engagements which will take him to England, Scotland, Ireland, France, Belgium and Germany. He will read a paper on Semisteel, at the International Foundry Trades Exhibition and annual meeting of the Instititon of British Foundrymen, to be held in Birmingham, June 15 to 24.

Alexander C. Brown, president of the Brown Hoisting Machinery Co., has been made chairman of the Cleveland chamber of commerce committee on labor relations. Others on the committee include C. K. Brooks, manager of the National Malleable Castings Co.; N. J. Clarke of the Lake Erie Bolt & Nut Co.; John G. Jennings of the Lamson & Sessions Co.; Stephen W. Tener of the American Steel & Wire Co.; and H. A. Rock of the Van Dorn Iron Works.

Pittsburgh Foundrymen Plan A. F. A. Trip

J. M. Ryan of the Stewart Mfg. Co., Chicago, described "Bearing Metals" for the members of the Pittsburgh Foundrymen's association at their May meeting held in the General Forbes hotel, Pittsburgh, May 15. He went into particulars concerning the manufacture of a new bearing and bushing metal and gave results of various experiments which have been conducted both in and out of actual service.

Officers for the foundrymen's organization to serve during the ensuing year were elected at this gathering as follows: President, Samuel B. Cuthbert of the Carnegie Steel Co., and vice president, John W. Guay of the Fort Pitt Steel Casting Co. Secretary-Treasurer William J. Brant, Bessemer building, Pittsburgh, was re-elected and the following new executive committee appointed: F. H. Clay, Allegheny Steel Co.; John Field, Union Steel Casting Co.; H. P. Spilker, the Sterritt-Thomas Foundry Co.; W. B. Robinson, *The Iron Age;* and Thos. A. Reynolds, McConway & Torley Co.

Plans were made to attend the convention of the American Foundrymen's association at Rochester, N. Y., June 5 to 9 in a body and a committee appointed to arrange for the local organization's annual outing to be held in June.

Convention and Exhibition Notes

GOVERNOR ALLEN of Kansas has accepted an invitation to be the banquet speaker at the American Foundrymen's association convention to be held at Rochester, N. Y., June 5 to 9.

To take advantage of reduced railroad fares to Rochester for the convention it will be necessary for each person to secure certificates from the office of the secretary of the association, Exposition park Rochester, N. Y. Write today.

Newark Association Re-elects Officers

All officers of the Newark Foundrymen's association were re-elected for the ensuing year, at a dinner in Newark, N. J., May 18. However, three new members were elected to to the executive committee, as follows: J. A. Parsons, Bethlehem Steel Co.; E. M. Taggart, J. W. Paxson Co., Philadelphia, and J. E. Berlendach, Bierman-Everett Foundry Co., Irvington, N. J.

Franz Nielson, New York, for the past 17 years active in trade association work, spoke on the evils of cut-throat competition and suggested several methods for greater co-operation among the foundrymen. Mr. Nielsen emphasized the importance of statistical information, uniform costs and open prices. He believed the government's present questioning attitude toward open price associations was temporary, and that regulations would be effected which would insure the future of such organizations.

Officers of the association are as follows: President, J. S. DeHart, Isabel-Porter Co., Newark; vice president, J. L. Carter, Barlow Foundry Inc., Newark; treasurer, J. A. Williamson, Isabel-Porter Co.; and secretary, W. H. Nantz, Atlas Foundry Co., Irvington, N. J.

A. S. T. M. Program Will Interest Foundrymen

The advance program for the twenty-fifth annual meeting of the American Society for Testing Materials to be held at Atlantic City, June 26 to 30, indicates many topics of interest to foundrymen. Nonferrous metals and alloys will be discussed at the first session, Tuesday morning at 9:30. Reports will be given of committee B-2, on Nonferrous Metals and Alloys, William Campbell, chairman, and committee E-4, on Metallography, W. H. Basset, chairman. Among the papers to be read at this session is one on Physical Properties of Some Copper-Silicon-Aluminum Alloys When Sand Cast, by E. H. Dix, Jr. and A. J. Lyon. A feature of the second session ot be held Tuesday afternoon is a discussion on pig and cast iron, following a paper by William R. Webster in which he will consider the physics of cast iron. Committee A-3, on cast iron, Richard Moldenke, chairman, and committee A-7, on malleable castings, H. E. Diller, chairman will present reports at this session. The report of the committee on cast iron will include a presentation of revised specifications for foundry pig iron and for chilled cast-iron wheels, also a new specifications for *high-test* gray-iron castings or what are generally known as semi-steel castings. These specifications call for higher transverse and tensile strength than are required by the present specifications for gray-iron castings. The malleable castings committee will propose a modification of the test bar of the present specifications and an increase in the requirements for tensile strength and elongation.

The steel session to be held Wednesday at 9:30 A. M. will open with the annual report of Committee A-1, on Steel, followed by a paper on the Tensile Properties of Steel Castings, by Lawford H. Fry, introducing a general discussion on steel castings.

Southern Metal Trades Meet in Savannah

The annual convention of the Southern Metal Trades association will be held June 19 and 20 at Savannah, Ga. The program for the first day will include an address of welcome by Hon. Murray M. Stewart, mayor of Savannah, response by Horace Lanier, president, West Point Iron Works, West Point, Ga.; announcements; reports of offices, including the annual address of the president, G. F. Meehan, Ross-Meehan Foundries, Chattanooga, Tenn.; secretary's annual report, W. E. Dunn, Jr.; treasurer's annual report, J. Wayne Moore. After the appointment of committees an address on "Signs of the Times" will be delivered by T. M. Cunningham, president Chatham Savings & Loan Co., Savannah, Ga., followed by an address on "Side Lights on Cupola Practice" by Pat Dwyer, engineering editor, THE FOUNDRY, Cleveland. The annual banquet will be held at 7 p. m., Monday, June 19, in the banquet room of the hotel Savannah. On Tuesday, the convention will receive reports of committees and elect officers for the coming year. The session will adjourn at 2 p. m. for an outing to Tybee, Thunderbolt and other points of interest.

Dr. Henry M. Howe

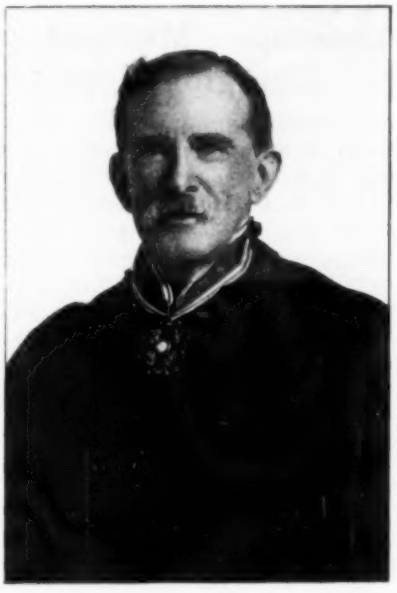
Dr. Henry M. Howe, eminent metallurgist and educator, professor emeritus of metallurgy, Columbia university, died May 14 at his home in Bedford Hills, N. Y.

Dr. Howe, who was 74 years old, was a son of Dr. Samuel Gridley and Julia Ward Howe, author of the "Battle Hymnn of the Republic." He was born in Boston and was graduated from Harvard in 1869. Two years later he was graduated from the Massachusetts Institute of Technology and the following year took his M. A. degree at Harvard. In 1905, he received a degree of L.L.D. from Harvard and Lafayette. He became professor of metallurgy at Columbia in 1897.

Dr. Howe was president of the American Institute of Mining Engineers in 1893, and in that year was also president of the jury of mines and mining at the Chicago exposition. He was also a member of the jury at the Paris exposition of 1889 and 1900. For three terms he was president of the Alumni association of the Massachusetts Institute of Technology.

He was an honorary member of the Russian Imperial Technical society, the British Institution of Mining and Metallurgy and the Swedish Royal Academy of Science. In addition he was a member of many other organizations, and was a Chevalier of the Legion of Honor. In 1906, he was made a knight with star of the First Order of St. Stanislas, Russia. He was a member of the technical clubs of New York and Boston and of the Century and Harvard clubs.

Dr. Howe made many valuable literary contributions on the subject of metllurgy, including "Iron, Steel and



DR. HENRY MARION HOWE

Other Alloys," "Metallurgy of Steel," and "Copper Smelting."

Dr. Howe was an honorary member of the American Iron and Steel institute; president of the International Association for Testing Materials, and president of the American Society for Testing Materials. He was also a member of the Societe d'Encouragement pour L'Industrie Nationale, of France.

Dr. Howe was the recipient of the Bessemer gold medal, Gold Medal of the Verein zur Beforderung des Gewerbfleisses, of Germany, and the Elliot Cresson gold medal of the Franklin institute.

In 1880-82, he designed and built the works of the Orford Nickel & Copper Co., Orford, N. J.

Metal & Thermit Corp., New York, announces the removal of its Pittsburgh branch office from 1427 Western avenue, to 801-807 Hillsboro street, Corliss Station, Pittsburgh.

The Chicago sales office of the Whiting Corp., Harvey, Ill., has been removed from 1245 Marquette building to 495 Monadnock building.

Book Review

Foundrymen's Handbook; cloth 309 pages, 6 x 9 inches; published by the Penton Publishing Co., Cleveland, and furnished by THE FOUNDRY for $5.00, postpaid.

As its name implies, the Foundryman's Handbook is a ready reference work of classified information of the gray iron, steel, malleable iron and nonferrous metal branches of the casting industry. The data contained therein is equally valuable to the patternmaker, to the foundry executive and to the progressive foundry operative who is ambitious to advance himself in his vocation. This handbook constitutes the first compilation of selected foundry data to be offered to the industry and represents a search for material extending over a period of about 12 years. Much of the information contained in this handbook previously has appeared in the data sheets which constitute so valuable a feature of every issue of THE FOUNDRY. However, before compilation in permanent form these data sheets have been revised to accord with the latest and best practice and the specifications have been checked to May 1 this year. The Foundrymen's handbook treats of more than 300 subjects, including specifications relating to foundry practice, tables, etc. Accurate information will be found therein that will aid in solving the many problems that daily confront every casting manufacturer.

This handbook is divided into six general sections into which the subjects have been classified and which facilitate reference. Miscellaneous foundry data is contained in the first section, which, for example, includes useful formulas for facing mixtures, data regarding refractories, coatings for steel cores, cupola operation, chimney design, methods for estimating the tonnage of pig iron in plies, of coke in bins, etc. When making estimates on the prices of castings, one of the most perplexing problems involved is ascertaining their weights and one entire chapter is devoted to methods for making such computations. Many tables are included and details are given which will enable the estimator to ascertain the weight of a casting in any foundry metal and regardless of its shape. Nor has the patternmaker been overlooked. One entire section is devoted to this branch of the foundry industry, which includes tables, standards, methods of computation and general information relating to pattern shop practice.

For the manufacturer of nonferrous metal castings a careful selection of alloys in general use has been in-

cluded in this handbook and methods of mixing and melting are given, as well as characteristics and physical properties of these alloys. In recent years manufacturers and testing engineers have evinced increased interest in specifications for the casting industry and standards for gray iron castings, cast iron pipe, locomotive cylinders, scrap metal, etc., are included. The handbook concludes with a series of miscellaneous tables, such as gross tons in pounds, decimal parts of a gross ton, net and gross ton equivalents, weights of a square foot of various metals, table for changing centigrade to Fahrenheit, weight of steel in pounds, table for converting millimeters to inches, etc. For a work of this kind the index is an essential feature and in the Foundrymen's Handbook this is unusually complete with direct cross references. This handbook should constitute a part of the library of all affiliated with any branch of the foundry industry, as it will prove of inestimable value in obtaining quickly information heretofore to be had only from widely scattered sources.

Designs Safety Hook

A new safety hook has been placed on the market by Frank W. Trabold, 30 Church street, New York. This is designed for general purposes, but is recommended particularly for use in handling molten metal. The new device comprises a hook, a latch, a locking member and a swivel ring. The latch and the hook have a dovetail connection and will lock together with

SAFETY CRANE HOOK SHOWING METHOD OF LOCKING

a cam on the lock member which automatically comes into position when the hook is latched. The hook may be hung from a crane or hoist or may be fastened to a chain or rope on the swivel ring. When used in carrying ladles, the hook not only maintains an unbreakable connection while in use, but may be disengaged from a distance by a poker. It is claimed that failure of the hook under a heavy load is prevented by the design, since, as soon as strain develops, the hook bears upon the latch, thus throwing a portion of the load upon the latter, a feature which makes the hook especially desirable for the handling of ladles, as it has smooth rounded surfaces which are said to glide over obstacles that with some hooks often cause spattering of the hot metal. The hook is made in 1, 3, 15 and 25-ton sizes.

Develops Machine for Charging Cupola

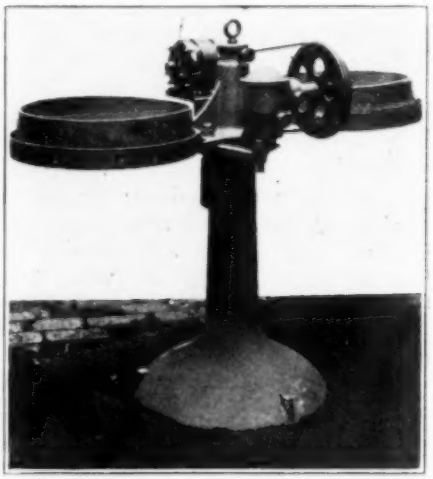
Reduction of fatiguing manual labor with its accompanying cost is one of the principal claims set up by the P. H. & F. M. Roots Co., Connersville, Ind., for a new type of cupola charging hoist. The hoist is operated by electrical power, either floor or overhead, and is designed to pick up pig iron or scrap by a magnet and fuel in a bucket and deposit the material in the cupola by means of a cantilever charging arm attached to the hoist frame. It is pointed out that by this method of charging all materials are deposited in the center of the cupola and concentric with the lining, thus evenly distributing each charge. It also is claimed that this method of charging increases the life of the lining by lessening abrasion by the descending metal.

A simple, quick-change, automatic hook on the magnet and bucket enables the operator to lower the hoist ropes with a *U*-bolt into the funnel-shaped hook, which by gravity slides down incline to the center line of the hook. When the hoist ropes are reversed upward, the *U*-bolt automatically engages the hook. The hook also forms a guard for ropes and magnet cable when hoisted and telescoped into the charging arm, thus preventing damage from heat and swinging while depositing the charge in the cupola. To release the hook the operator lowers the travel hoist until the ropes are on an angle, then the hoist ropes and *U*-bolt disengage the hook and slide up the incline and out of the hook casting. The hoist has a lifting capacity with magnet of from 300 to 600 pounds of pig iron or scrap; 400 to 500 pounds of fuel with bucket, and of 2000 pounds if used as a vertical lifting hoist without magnet or bucket. The hoist operates in the bottom flanges of standard I-beam section and is designed to travel around an 8-foot radius in the track.

Pedestal Riddle of British Manufacture

A new type of duplex sand sifter has been developed by the Adaptable Moulding Machine Co., Stanhope street, Birmingham, Eng. This device which may be driven by a 1/6-horsepower motor, or by a belt or even, if necessary, by hand, is shown in the accompanying illustration.

The apparatus consists of a heavy cast-iron standard at the top of which two riddle holders are mounted on a pivot bearing. A bevel geared swivel head connects with the riddle holders by a crank thus imparting an oscillating motion to the riddles similar to that which a good molder employs when riddling by hand. The riddles are placed at a convenient height so that the sand may be sifted



ELECTRIC, BELT, OR HAND DRIVEN DUPLEX SAND SIFTER, MADE IN ENGLAND—INSET SHOWS BELT DRIVE

directly into wheelbarrows, trucks, or any other form of conveyor. The sifter can be operated from any lamp socket or from a line shaft as may be desired. It is portable and may be picked up by means of the ring in the top of the standard. The base also is provided with bolt holes so that the machine may be fixed to the floor if desired.

G. M. Sherman has been appointed New England sales manager for the Keystone Refractories Co., 120-122 Liberty street, New York. Mr. Sherman, who formerly was connected with the Quigley Furnace Specialties Co., will maintain offices at 818 Hospital Trust building, Providence, R. I.

The Republic Carbon Co., Inc., manufacturer of carbon electrodes, has removed its sales office to Milwaukee. The manufacturing plant remains at Niagara Falls, N. Y.

Equipment Purchases Increase

Inquiries for Foundry Machinery and Supplies Continue to Grow and Orders Keep Pace—Strengthening Market Indicates Price Advances in Some Lines—New Projects Multiply

WITH the steady improvement in foundry operations, buying in both machinery and supplies is growing. New projects and replacements alike are bringing out inquiries. The Charleston Electric Steel Foundry Co., Charleston, W. Va. is contemplating the installation of a small cupola. Construction has been started on a new foundry for the Frick Co., Inc., Waynesboro, Pa. A. O. Frick is president of the company. The Ajax Electrothermic Corp., Trenton, N. J. recently sold two furnaces with a high frequency converter and vacuum attachment to the Dentist's Supply Co., York, Pa. The W. H. Howell Co., Geneva, Ill. is inquiring for an elevating foundry truck.

Outlook Bright in Pittsburgh District

PROSPECTIVE buyers of foundry equipment in the Pittsburgh territory are numerous and while occasionally a few orders are booked, the majority are deferring action. The complaint is general among sellers that much effort is expended on propositions only to have plans changed and then sometimes they are abandoned and entirely new ideas are worked up. Two or three complete foundry equipment installations are alive while at least three cupolas of capacities up to five tons are current. One of these recently was placed and later cancelled. One inquirer for a complete installation has just asked for revised figures all along the line. The possibility of higher prices now confronts purchasers, due to rising costs of raw material, starting with fuel. Already an advance of 15 per cent effective June 1 is announced by a manufacturer of industrial cars and kindred equipment. A nearby foundry company recently purchased an electric furnace, a number of flasks, etc., and recent purchasers of core ovens include the Lorain Steel Co., Johnstown, Pa., and the Coshocton Iron Co., Monongahela, Pa. Frequent orders are received for sand handling and mixing machinery, one motor-driven sand mixer from the Blystone Mfg. Co., Cambridge Springs, Pa., with screen being sold to a Pittsburgh district user this past week. Another buyer in Virginia purchased a blower from the P. H. & F. M. Roots Co., Connersville, Ind. and a few other blower orders are scheduled for early closing. A nearby foundry operator purchased a small crane, an elevator and a cupola from the Whiting Corp., Harvey, Ill., but has not completed his equipment purchases. Flasks, riddles and other small supplies are being sold practically every day in varying quantities, the demand for this character of equipment having improved considerably during the past two or three weeks. Recent sales of air compressors include an 8-inch x 8-inch compressor made by the Chicago Pneumatic Tool Co., New York, one 450-cubic foot capacity compressor of another make and a third of considerably smaller capacity. The largest crane award noted recently is that of the Union Iron Works, Erie, Pa., to the Northern Engineering Works, Detroit, for one 30-ton 71-foot 9¾-inch span electric traveling, two 15-ton, 36-foot 7½-inch span electric traveling and two 15-inch 24-foot 3½-inch span tower riveting cranes, all 3-motor. The Canonsburg Steel & Iron Works, Canonsburg, Pa., purchased a 7½-ton 3-motor 50-foot span crane from the Milwaukee Electric Crane & Mfg. Co. The Universal Steel Co., Bridgeville, Pa., is about to close on a 5-ton while the Greenville Steel Car Co., Greenville, Pa., is scheduled to take early action on a 10-ton. Several foundries in this territory recently have manifested interest in grinding machinery of various types. Inquiries for molding machines too are prolific and several sales have been consummated recently by prominent sellers in this district. Pre-convention molding machine business booked in this district is surprising. Recent orders received by the Herman Pneumatic Machine Co. include a large rollover machine and a core machine from the Advance Boiler Corp., Poughkeepsie, N. Y.; 10 small jarring machines, one large shakeout bumper and two large rollovers from the Commonwealth Steel, Granite City, Ill.; a large rollover machine to the Oil Well Supply Co., Oil City, Pa., and one large jar-ram, stripping-plate machine from the National Sanitary Mfg. Co., Salem, O., and the same class machine to the A. P. Smith Mfg. Co., East Orange, N. J. Numerous inquiries have been received by the same manufacturer, particularly from the West.

Eastern Inquiry Improves

SOME lines of foundry equipment are moving briskly in the East. These include sand blast equipment, sand cutters and flasks. Trading in molding machines and plain tumblers is characterized as fair. Buying still is largely for replacement purposes, although several new projects are being figured, including a plant for the Fisher Sweeney Bronze Co., Hoboken, N. J. Plans just completed by Lockwood Greene & Co., 101 Park avenue, New York city, call for a structure, 100 x 200 feet. An equipment list is likely to be issued at any time. Another project is that of the Eastern Foundry Co., Boyertown, Pa. The company is headed by E. M. Rhodes. A recent buyer is the Brooklyn Foundry Co., Brooklyn, which has closed on a used 2-ton handpower crane and also a 2-ton tramrail system, the latter order going to the Cleveland Crane & Engineering Co., Wickliffe, O. A list is expected to be issued shortly by the Reading Casting Co., Reading, Pa. whose plant was recently badly damaged by fire. Sellers are now adhering rigidly to their official prices, there being little or no shading in any quarter. However, while the tendency is upward, there has been no advance recently in official quotations.

Buying Broadens in Chicago

BUYING of foundry equipment is on a much broader scale at Chicago than for some time, but supplies apparently are not equally in demand. That much iron is being melted is indicated by the renewed demand for ladles and small equipment and tumbling barrels also are being added in many foundries, indicating a largely increased output. The Western Foundry, Chicago, is building an addition to contain a warehouse and japanning department. Frank D. Chase, Inc., is the engineer in charge. The Buckeye Steel Castings Co., Lima, Ohio, has installed a 1-ton converter outfit, supplied by the Whiting Corp., Harvey, Ill. The same seller has taken orders for two 42 x 60 tumbling barrels for the American Manganese Steel Co., Chicago Heights, Ill., two 42 x 60 tumbling barrels for the Sommerville Iron Works, Chattanooga, Tenn., three 36 x 48 tumbling barrels for the Cadillac Foundry, Cadillac, Mich., and two 48 x 81 tumbling barrels for the Central Foundry Co., New York City. The

Leonard & Baker Stove Works, Taunton, Mass., has bought a 64-inch cupola from the Whiting Corp. and the Two Wheel Windmill Co., at Hutchinson, Kans., has bought a 32-inch cupola from the same manufacturer. The Ford Motor Co. has increased its order for helical geared ladles with the Whiting Corp. by ordering 12 more of 1500 pounds capacity. The National Engineering Co. is shipping four sand mixers, one going to Texas, two to separate users in Massachusetts and one to Michigan. Some dealers find strong competition in second hand equipment, which is being offered at prices far below new material. Some of this is left over from war equipment and has not been used. Wm. Demmler & Bros., Kewanee, Ill. recently have installed air-operated core machines in the plants of the Ohio Brass Co., Mansfield, O., the Central Brass Co., Cleveland, and the Indiana Brass Co., Frankfort, Ind. The W. T. Garratt Co., San Francisco, at present is installing core machines purchased from the same company.

What the Foundries Are Doing

Activities of the Gray Iron, Malleable, Steel and Brass Shops

A 1-story bronze foundry will be erected at Long Island City, N. Y., by Oscar Berger.

The capital stock of the New York Brass Foundry Co., New York, recently was increased from $10,000 to $50,000.

Capitalization of the B. M. Martin Brass Works, New York, recently was increased from $10,000 to $30,000.

The pattern shop of the American Sewer Pipe Co., North Case avenue, Akron, O., recently was damaged by fire.

Swinton & Co., 47 Main street, Port Jarvis, N. Y., are reported planning the erection of a foundry building, 1-story, 72 x 152 feet.

The Calumet Tank & Mfg. Co., Hammond, Ind., is reported planning the erection of a foundry building, 1-story, 60 x 140 feet.

The Segel Lock & Hardware Co., New York, has let the contract for the erection of a machine shop at Springdale, Conn., to be 3-stories, 30 x 140 feet, and a 1-story foundry addition.

Plans now are being prepared by the Transfer Metal Casting Co., Doremus avenue, Newark, N. J., for the erection of a 1-story foundry.

Erection of an addition to its plant is reported being planned by the Santa Fe Foundry Co., D. and Clinton streets, Richmond, Cal. G. W. Penning is manager of the plant.

The Western Die Casting Co., 2927 Newbury street, Berkeley, Cal., is reported planning the erection of a plant at Vallejo, Cal., to be devoted to the manufacture of carburetors, etc.

The Empire Brass Foundry, 128 Wellington street, Montreal, Que., is reported planning to erect an addition and make numerous alterations to its foundry on Nazareth street.

The Logan Foundry & Machine Co., Logan, O., is enlarging its plant. Two new buildings, one 60 x 100 feet, and the other 60 x 90 feet, now are under construction.

The portion of the plant of the Fischer-Sweeney Bronze Co., 1301-11 Grand street, Hoboken, N. J., which was recently damaged by fire, will be rebuilt. Plans are now being prepared.

The St. Paul Brass Foundry Co., Frederick Oshrlein manager, 288 Minnesota avenue, St. Paul, is reported having plans prepared for the erection of a foundry building, 1-story, 36 x 50 feet.

Capitalized at $75,000 the Republic Die Casting Co., New York, recently was incorporated by T. Powell, H. Davis and T. Hart. The company is represented by G. M. Sachs, 276 Fifth avenue, New York.

A large part of the plant of the Reading Casting Co., Reading, Pa., recently was damaged by fire. Some valuable patterns were destroyed.

Plans are being prepared for the erection of a steel foundry building for the C. L. Dorer Foundry Co., Martin's Ferry, O.

Reports are current to the effect the Centre Foundry & Machine Co., Wheeling, W. Va., shortly will start work on the erection of a modern plant building on a site which it recently purchased. It is understood the present plant of the company has b en purchased.

The American Car & Foundry Co., it is reported, is to construct a plant for its tool division in Detroit, instead of Jackson, Mich., as originally planned. The company has property holdings in Detroit valued at $2,000,000 and it was this which influenced officials in favor of Detroit, according to the statement.

A petition in bankruptcy recently was filed against the Southern Foundry & Mfg. Co., Owensboro, Ky. The company has assets of $200,000 and claimed liabilities of $207,000. The petition was filed in the name of the Goodrich Rubber Co.; the American Rolling Mill Co. and the Ohio Pattern Work & Foundry Co.

The West End Foundry Co., West Park, Cleveland, O., recently was incorporated under the laws of Ohio with a capital stock of $5000. Incorporators of the company included Anton Kotzab, Joseph Zoorela, Anton Lohn, Stanislaw Bartling, 12611 West Madison avenue, West Park, and Andrew J. Meener. Plans of the company have not been announced, but it is understood the company will engage in the manufacture of burners, etc.

Construction work has been started on a new foundry building for the Frick Co., Inc., Waynesboro, Pa., agricultural implements and machinery. The building will be 150 x 300 feet, will be fully equipped and will have a capacity of about 60 tons of gray iron castings daily. A pattern storage building, 3-stories, 50 x 160 feet, also is being built, the upper floor of which will be used as a pattern shop. A. O. Frick is president of the company and Ezra Frick, vice president and general manager.

Reorganization of the Connecticut Electric Steel Co., Hartford, Conn., is expected to follow its purchase by W. M. Taggart & Co., New York. Present plans call for reincorporation of the company as the Electric Foundry Co. and its operation by July 1. The company, which was organized in 1916, produces steel ingots and castings, and nickel, chrome, carbon and alloy tool steels, operating two electric furnaces. The plant has been idle for about one year. Officers of the company are: President and treasurer, Edwin L. Wilson; secretary, Samuel Ferguson, and sales manager, Charles Margerum.

Latest addition to the list of foundries in the Milwaukee district is the Wisconsin Gray Iron Foundry Co., which recently was incorporated with a capital stock of $30,000 to take over a foundry at Thirty-ninth avenue and Burnham street, Milwaukee. It will start regular operations shortly. John A. Burke is president and general manager of the company. He is a veteran foundryman and will be assisted by E. E. Freeman, as general superintendent. Frederick L. Sivyer, president of the Northwestern Malleable Iron Co., Milwaukee, is vice president; Mackey Wells, treasurer, and Leo A. Mullaney, secretary.

The Bucyrus Co. has under way extensive enlargements to its plants at South Milwaukee, Wis., and Evansville, Ind. These changes and rearrangements are planned to take care of the increasing volume of business and to enable the company to manufacture more economically. In the South Milwaukee plant, where all the larger machinery is built, a new gray iron foundry is now under construction, 276 feet in length. The old gray iron foundry, now the south end of the steel foundry, is being converted into a cleaning room with annealing ovens, sand blast rooms and a welding room. A large addition is also being made to the steel foundry molding floor, and an electric furnace is being installed.

New Trade Publications

BRONZE ALLOYS—The Lumen Bearing Co., Buffalo, has published a 22-page illustrated booklet in which bronze alloys are described. The booklet is really a ready reference to the company's bronze castings products. Specifications are given. Service, to which the various alloys are adaptable, are pointed out.

WOODWORKING MACHINE—The Hutchinson Mfg. Co., Norristown, Pa., is circulating an illustrated folder in which a newly designed woodworking machine is described. In the folder the company offers a prize for a name for the new tool, which, it is claimed, will perform 15 different woodworking operations.

CRANES—The Northern Engineering Works, Detroit, has published a small booklet in which cranes and hoists manufactured by the company are illustrated, some of the illustrations being of actual installations. The products illustrated include electric cranes, electric hoists, air hoists, air jacks, handpower cranes, jib and pillar cranes, monorail cranes, monorail trolleys, grab bucket cranes, stacking cranes, gantries, etc.

HEATING SYSTEM.—Skinner Bros. Mfg. Co., Inc., St. Louis, has published a 20-page illustrated booklet in which a factory heating system is described and illustrated. This heating unit is constructed of heavy steel plates and angles, the upper part being equipped with coils of steam pipe. The pipe is so arranged that it may be easily removed for repairs. The blower or fan is placed beneath the pipe in the same enclosure. Air, drawn in by the fan from two sides, is forced upward against the steam-heated coils and heated, passes out at the top. Advantage is taken of the natural law that heated air rises, and the fullest benefit of this law is derived.